Summer Meeting Issue

SAE Journal

IN THIS ISSUE . . .

TO POWER FUTURE VEHICLES . . .

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JULY 1957

Published by The Society of Automotive Engineers

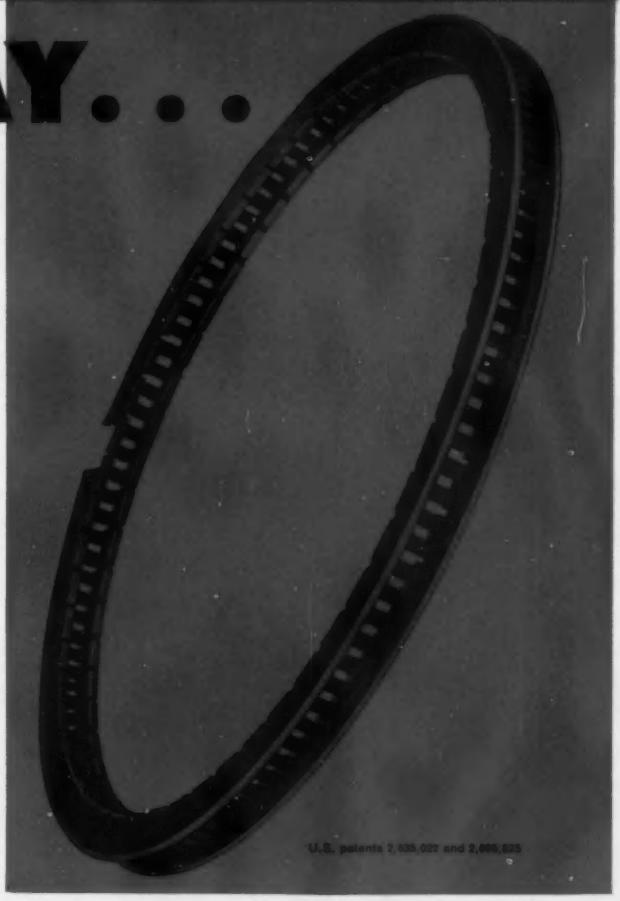
YESTERDAY...

when compression ratios were 3 to 1, any good oil ring would do...as in this wonderful 1909 Rambler. A 32-H.P. four-cylinder engine powered this car when it broke the Los Angeles-San Diego record, covering 330 miles in 10 hours and 32 minutes back in 1909. Note the fancy "swept-wing" front fenders!

TODAY...

it takes the PC type "98" chrome oil ring!

The Perfect Circle Type "98" Chrome oil ring was specifically designed to meet the exacting demands of today's high-compression engines. Featuring universal application, bottomless and conventional grooves, all depths, the PC Type "98" oil ring was the first to have a patented side-sealing action with multiple tiny springs that exert both side and radial pressure. And of utmost importance, Type "98" Chrome Oil Rings provide maximum oil drainage! Perfect Circle Corporation, Hagerstown, Ind.; The Perfect Circle Co., Ltd., 888 Don Mills Road, Don Mills, Ont.



U.S. patents 2,635,022 and 2,695,825

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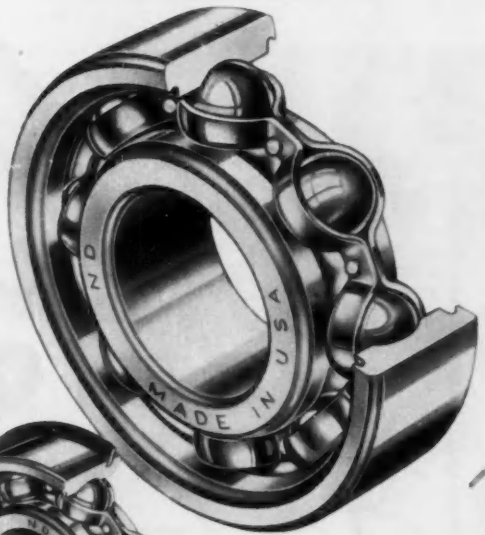
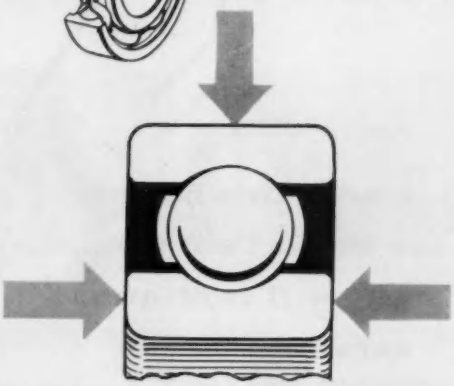
Preferred by more people than any other brand!

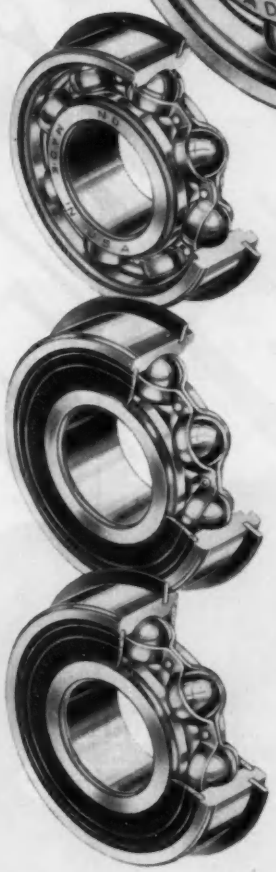
FACTS

about

NEW DEPARTURE BALL BEARINGS







The Word *Versatile*

Fits Like A Glove!

Fits because—this basic New Departure ball bearing, more widely used than any other antifriction type, does much more than carry RADIAL loads—it locates the shaft it supports against THRUST LOADS FROM BOTH DIRECTIONS equally well!

Fits because—with a simple snap ring added, it does away with inside housing shoulders, simplifying mounting and cutting machining costs!

Also—with efficient Sentri-Seal added, without change in exterior dimensions, it eliminates a separate outside closure—assures protection from outside dirt!

And—with Sentri-Seals on both sides, this same basic bearing does away with all separate seals, eliminates all need for lubricating fittings—requires no attention for greasing!

Finally—it is a long-lived, non-separable unit that calls for no shims or other devices for periodical adjustments.

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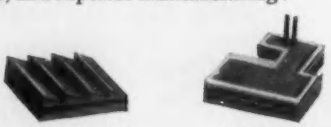

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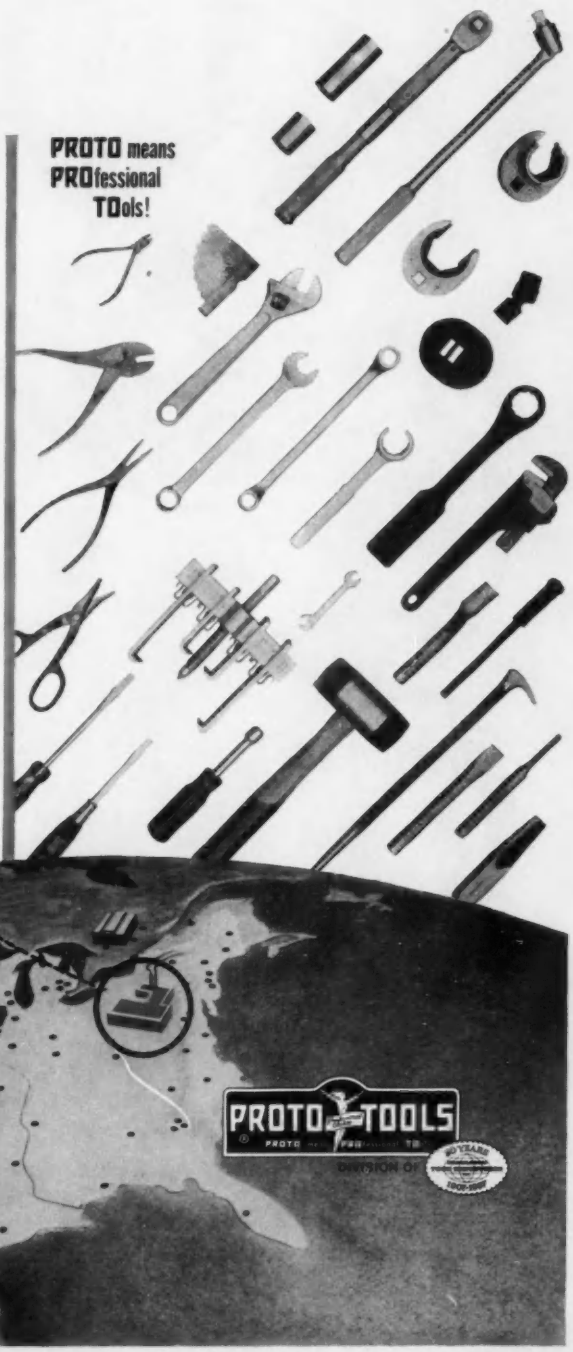
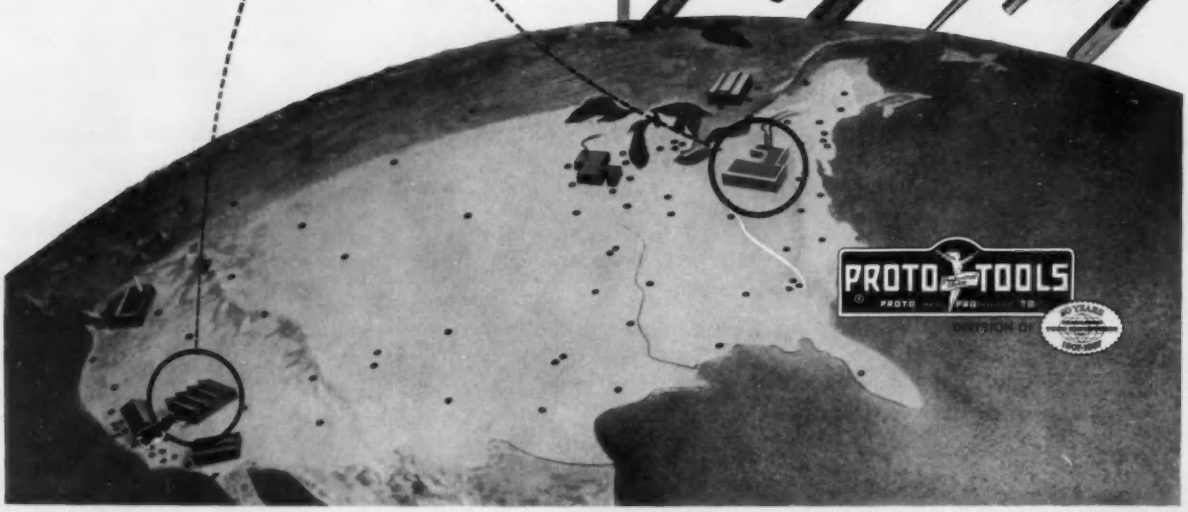
LOS ANGELES, CALIF.

583 ALLEN STREET
JAMESTOWN, NEW YORK

PROTO means PROfessional TOols!





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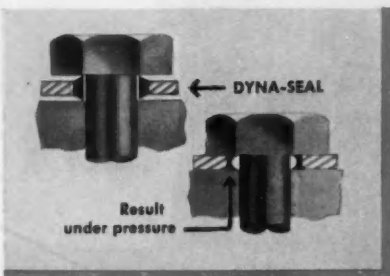
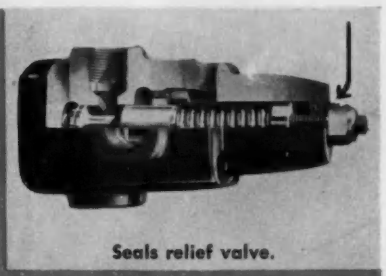
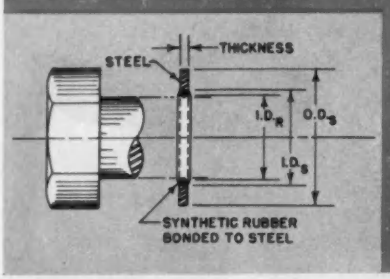
Problem A simple, low cost solution to a face-to-face sealing problem

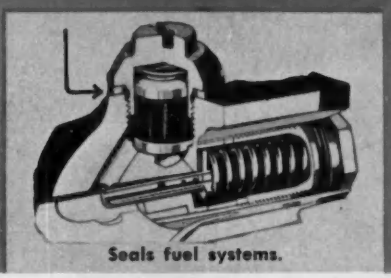
Solution Precision Dyna-seal®



Seals hydraulic control manifold.


Seals relief valve.

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Easy-to-handle one piece seal of rubber bonded to a steel washer.

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- Reusable—cuts maintenance.

Available in-stock sizes for No. 5 screw to 1¼" bolt or from 1/8" to 1¼".

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110-6	.138	.208	.328	.158	.041
110-8	.164	.234	.364	.184	.041
110-3/16	.190	.281	.422	.220	.054
110-7/32	.216	.307	.453	.246	.054
110-1/4	.250	.341	.516	.280	.054
110-5/16	.312	.403	.594	.342	.054
110-3/8	.375	.466	.687	.405	.054
110-7/16	.437	.528	.766	.467	.075
110-1/2	.500	.601	.875	.540	.075
110-9/16	.562	.663	.969	.602	.075
110-5/8	.625	.726	1.062	.665	.075
110-11/16	.687	.788	1.156	.727	.090
110-3/4	.750	.865	1.266	.800	.090
110-13/16	.812	.927	1.359	.862	.090
110-7/8	.875	.990	1.453	.925	.090
110-15/16	.937	1.052	1.531	.987	.090
110-1	1.000	1.135	1.656	1.050	.090
110-1 1/8	1.125	1.260	1.844	1.175	.090
110-1 1/4	1.250	1.385	2.016	1.300	.134

Write for your free copy of the Precision catalog on Dyna-seals.

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"O" Ring and Dyna-seal Specialists

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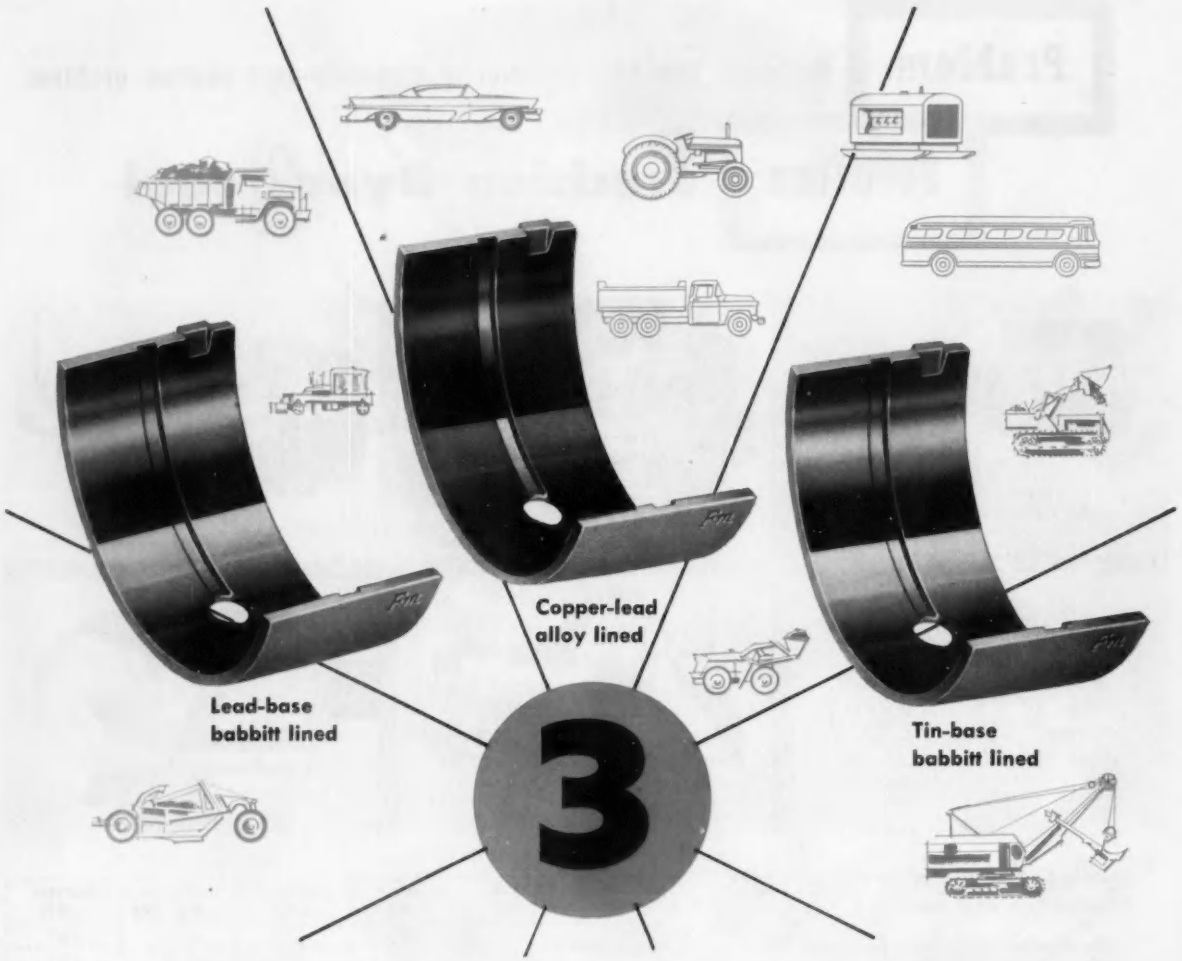

bearings that meet the widest range of engine applications

Across the broad range of engines which impose light or medium loads on the bearings, tin-base and lead-base babbitt-lined bearings are the economical, dependable "work horses". For the newer engines imposing heavy loads, bearings lined with copper-lead alloy are the answer. Using our patented, low oxide copper-lead powder alloy as the heart of the lining, steel-backed copper-lead bearings produce new performance standards in heavy-duty operation. For complete information address:

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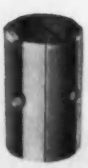
Rolled, Split Bushings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Bearing-surfaced Thrust Washers

FEDERAL Mogul

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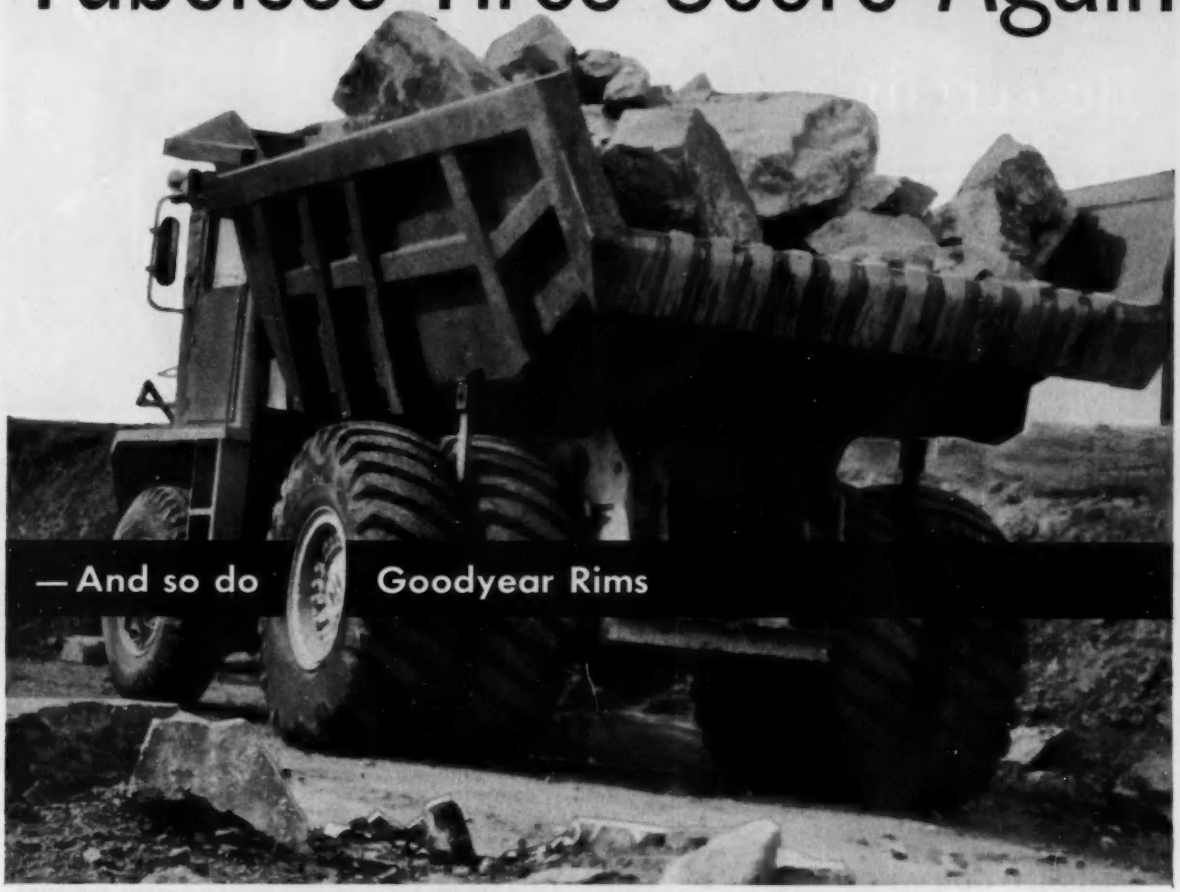
RESEARCH · DESIGN · METALLURGY · PRECISION MANUFACTURING

Tubeless Tires Score Again



NOTHING'S tougher on tires—or rims—than running over jagged rocks, as you may have good reason to know.

That tubeless tires can be used on such a job, and so effectively, is in large measure due to Goodyear's development of rims to fit every type of vehicle, from the smallest truck to the largest earth-mover.

Goodyear's matchless experience in building rims for every type of vehicle has produced numerous advances. When you specify Goodyear rims you get:

Unusual Strength: Thanks to an exclusive double-welding process, and added support at points of greatest stress, present-day Goodyear Rims are far stronger than previous rims.

Ease of Tire Mounting: No tube and flap troubles.

Special Tools: Goodyear alone provides both hydraulic and hand tools especially made for off-the-road equipment.

Bond-a-Coat Finish: This protective coating affords long-lasting resistance to rust and corrosion.

Got a truck rim problem? Goodyear will help you solve it.

If you have a rim problem, why not talk it over with the G.R.E. (Goodyear Rim Engineer). He'll save you time and money by helping you select the type and size of rim best suited to your needs. Write him at Goodyear, Metal Products Division, Akron 16, Ohio, or contact your local Goodyear Rim Distributor.

Buy and Specify **GOODYEAR**

MORE TONS ARE CARRIED ON GOODYEAR RIMS THAN ON ANY OTHER KIND

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Be certain *you*

MAKE THE *RIGHT* CHOICE!

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ASK YOURSELF THESE QUESTIONS —IT WILL PAY YOU.

CHALLENGING OPPORTUNITIES IN

• AVIONICS
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Whether a Recent Graduate making his first choice or a veteran Engineer seeking that permanently RIGHT position, ask yourself the following questions:

MY TALENTS ARE BEST SUITED FOR?
Engineers come all sizes, shapes and potentials. G.M.'s policy of decentralization creates individual opportunity for development and advancement.

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At G.M. these two questions are best answered by another question—"How high is up?" Earnings both present and future are entirely dependent upon you. At AC you determine your earnings.

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AC has been designated the official ELECTRONICS DIVISION for *all* General Motors Divisions. We are permanently dedicated to the research, development and manufacture of things Electronic . . . making America so it's safer and better.

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At AC you enjoy working with the latest and the finest of equipment and with the top men in the field.

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Write us in strictest confidence . . . you will hear from us by return mail. Send us the coupon below . . . YOUR FUTURE DEPENDS UPON IT.

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☐ I will send it at a later date.

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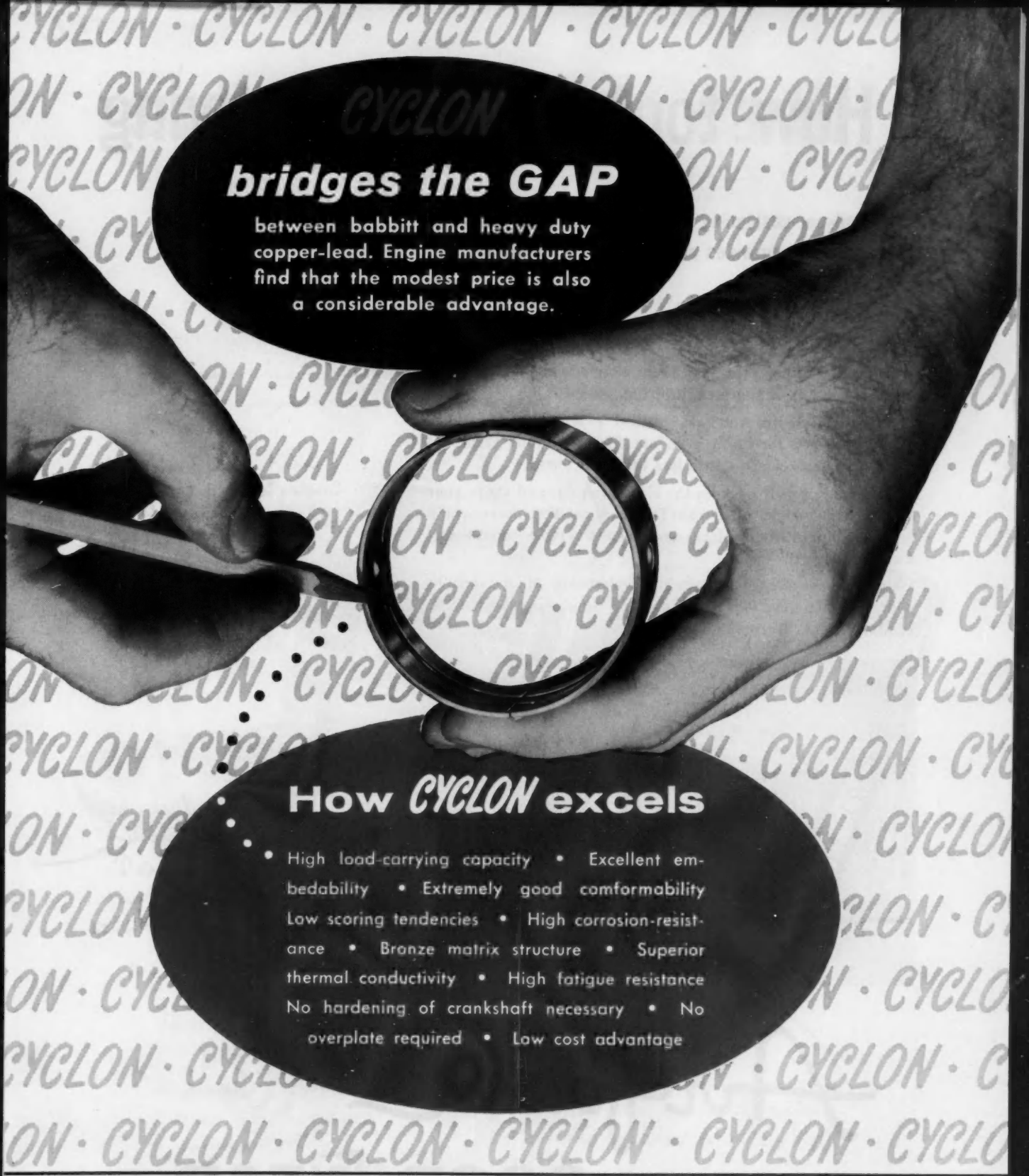
City_____ Zone_____ State_____


CYCLON
bridges the GAP
between babbitt and heavy duty copper-lead. Engine manufacturers find that the modest price is also a considerable advantage.
How CYCLON excels
• High load-carrying capacity • Excellent embedability • Extremely good comformability Low scoring tendencies • High corrosion-resistance • Bronze matrix structure • Superior thermal conductivity • High fatigue resistance No hardening of crankshaft necessary • No overplate required • Low cost advantage

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MANUFACTURERS OF ORIGINAL EQUIPMENT SINCE 1925

How to bring a high-flying

New Goodyear cushioning medium makes the impossible practical—provides new R-O-O-M for comfort!

NEVER SAY "IT CAN'T BE DONE"—unless you mean it can't be done by the old, conventional methods.

For when you employ AIRFOAM as a *designing aid* and *basic component* (rather than just as an alternate cushioning) you open new vistas of space engineering.

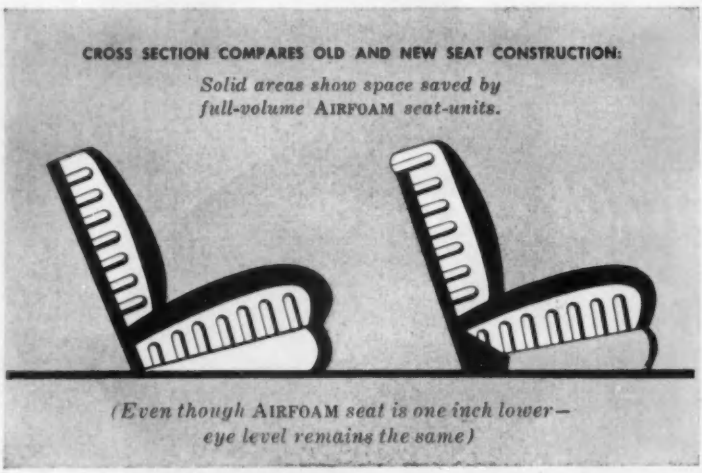
You see, full-depth AIRFOAM, molded to your specifications, eliminates need for bulky elements—fits *more* good style and *more* luxurious comfort into *less* interior cubage.

Once you turn your back on the old no-can-do—and share your seating problems with Airfoam Development Engineers—you'll find your highest-flying ideas come down to earth without losing a single feather!

We've got a lot of answers here at Development. Maybe some fit your favorite questions. Just contact Goodyear, Engineered Products Dept., Akron 16, Ohio.

Isn't it difficult and costly to keep this piping uniform?

NO. It's molded-to-shape AIRFOAM—can be quickly duplicated everytime.


CROSS SECTION COMPARES OLD AND NEW SEAT CONSTRUCTION:
Solid areas show space saved by full-volume AIRFOAM *seat-units.*
(Even though AIRFOAM *seat is one inch lower—eye level remains the same)*

Don't individual seat bases cost plenty?

Not when this simple. The AIRFOAM just makes them look intricate.

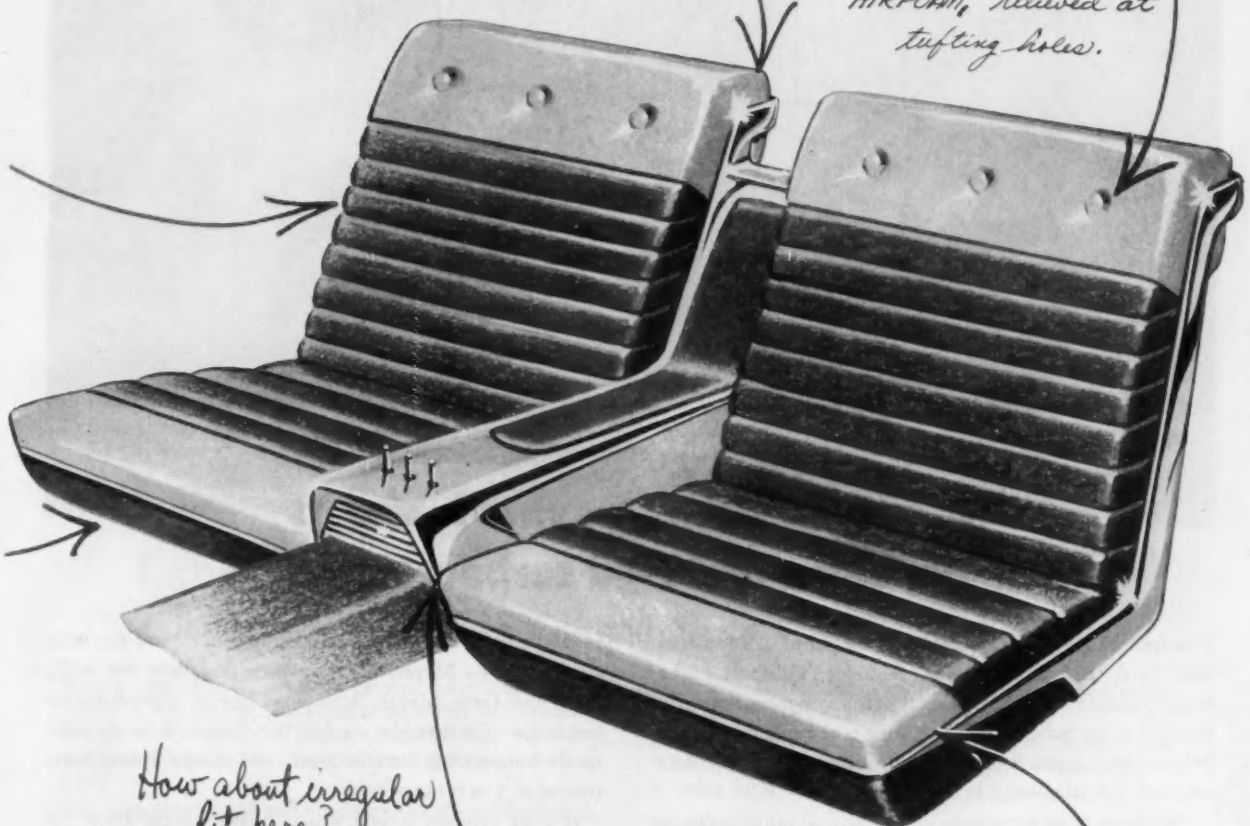
Airfoam

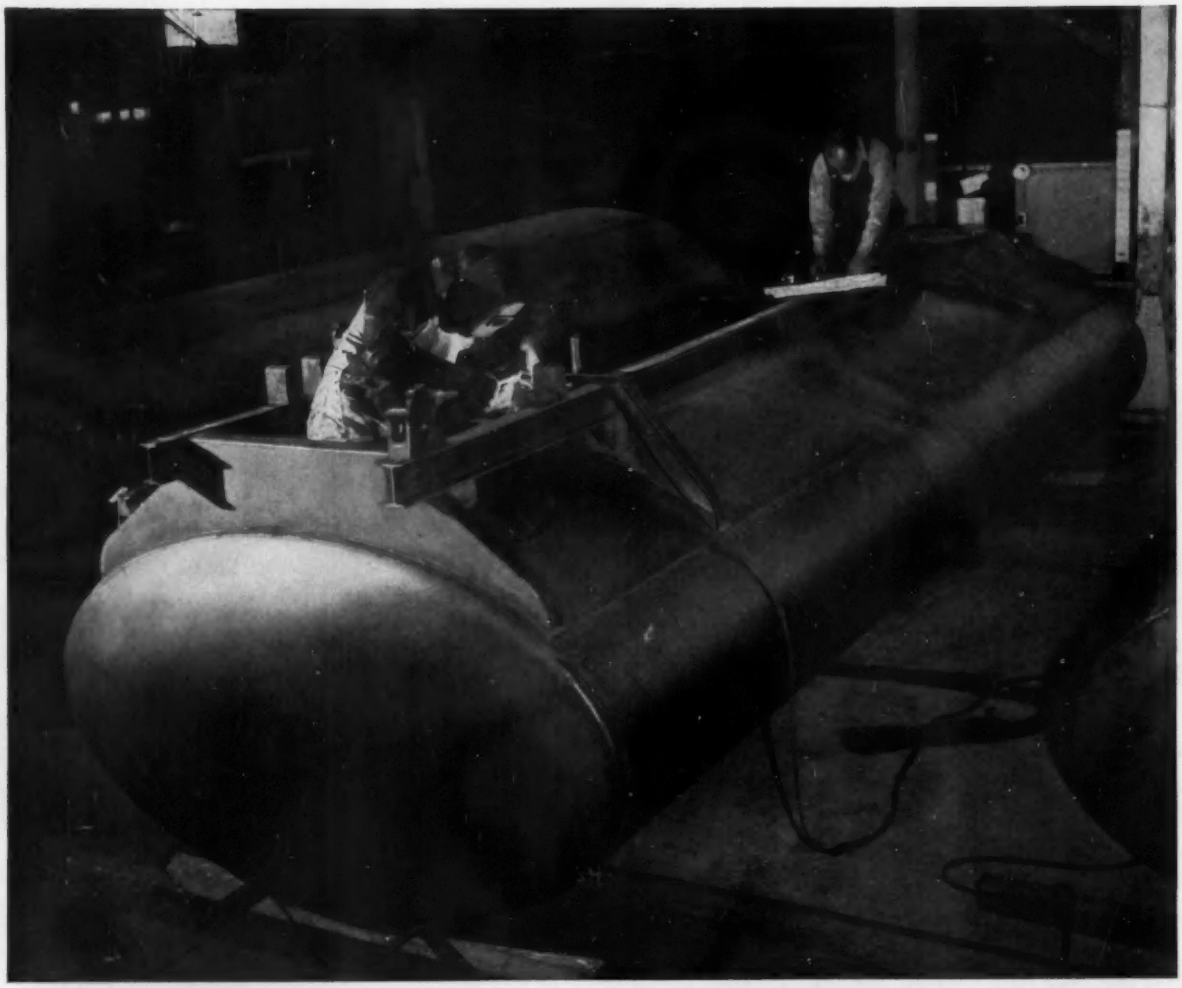
MADE ONLY BY GOODYEAR

THE WORLD'S FINEST, MOST MODERN CUSHIONING

Airfoam—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

seat idea down to earth


How about these hard corners?
There aren't any. Molded AIRFOAM needs no edge-braces or corner-braces.
Doesn't this tufting cause hard spots?
NO. It's all molded AIRFOAM, relieved at tufting holes.
How about irregular fit, here?
NO problem. Full-volume AIRFOAM tailors this point perfectly.
How can you build comfort into such a low seat?
Let full-depth AIRFOAM do all the cushioning work. Remember—it's an entirely new cushioning medium!



Putting the finishing touches on a 4600-gal tank trailer in the shops of Industrial Steel Tank and Body Works, Berkeley, California. Tank was welded from 12-ga Mayari R sheets.

They use 12-ga Mayari R sheets in place of 10-ga carbon steel

This tank trailer, being assembled in the shops of Industrial Steel Tank and Body Works, Berkeley, California, is a hot-oil carrier to be used in road construction jobs. Formerly made of 10-ga carbon steel sheets, the tanks are now welded from 12-ga Mayari R high-strength, low-alloy steel sheets with substantial savings in deadweight.

"We have wide acceptance of our hot oil tanks made of 12-ga Mayari R," say the Industrial Tank people, adding: "In working with Mayari R there are no welding problems. It is easy to work with and it is a good, tough piece of material for the job, with terrific savings because of the lighter-weight sheet we can use."

More and more manufacturers of tankers like this, as well as buses, walk-in panels, dump trucks and flat-beds are turning to Mayari R. Shop men find they can weld, work and form Mayari R without special equipment or techniques. Owners like the fact that Mayari R holds paint much longer than carbon steel, and resists atmospheric corrosion 5 to 6 times better.

If your product is one which might benefit from the superior properties of Mayari R sheets, a Bethlehem representative will be glad to discuss it with you. You can reach him through the nearest Bethlehem district sales office.

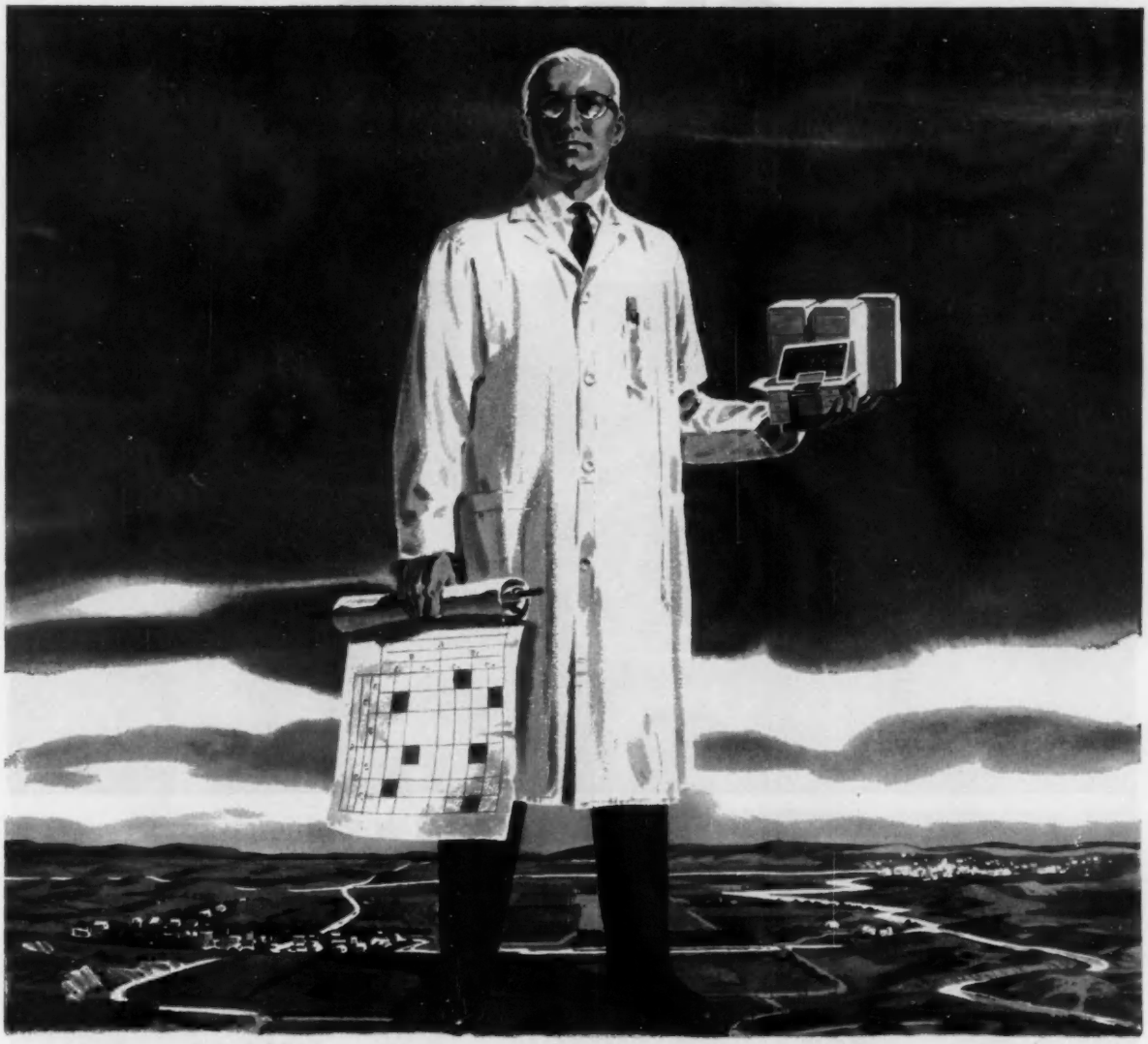
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

Export Distributor: Bethlehem Steel Export Corporation

Mayari R...High-Strength, Corrosion-Resisting Steel

BETHLEHEM STEEL



Latin Square, Univac and 36 years experience

all three help assure National Seals are best engineered

Univac you know, experience you know; the Latin Square? An ancient, half-forgotten solver of problems having many variables. Today, National Seal engineers use it to reduce exploratory engineering time as much as 75%.

Old, new, time-tested and visionary—National Seal engineers embrace every approach that can help keep National Seals the best engineered in America. Results have been good. Syntech®, the milestone in synthetic rubber seals and Micro-Torc®, major forward step in leather seals, are but two examples.

National Seal's advanced engineering, in plant or field, is ready now to help you solve sealing problems. This help is yours for a telephone call.

VITAL: Whatever seals you buy, save trouble and expense later on by specifying them "on the board." For safety, have specifications checked by a National Seal engineer.

NATIONAL SEAL Division, Federal-Mogul-Bower Bearings, Inc.

General Offices: Redwood City, California; Plants: Van Wert, Ohio, Redwood City and Downey, California

36th Year

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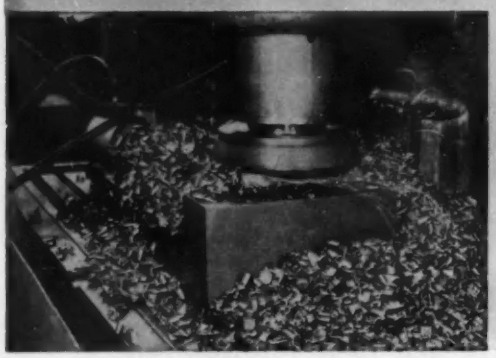
CARMET®

STEEL-CUTTING CARBIDES

1 INCREASE PRODUCTION 2 GIVE UP TO 50% LONGER LIFE



DETAILS OF JOB ILLUSTRATED

Machine	Sundstrand Rigid Mill
Cutter Size	10" Diameter
No. of Teeth	12
Carbide Inserts (grade)	Carmet CA-610
Rate of Travel	400 S.F.P.M.
Table Speed	10 in. per minute
Depth of Cut	½ inch
Material	1095 Cold Drawn Shank Steel, 200 Brinell

READY FOR YOU

Complete Technical and Shop Data on the Carmet "CA-600 Series" of special steel-cutting Carbides

Write for Your Copy

ADDRESS DEPT. SA-91

Here's something *special* for you: the new Carmet steel-cutting grades of carbide, called the "CA-600 Series." One of the grades is shown above in a milling operation—a tough job where the major requirement was continuous production. Cutters equipped with Carmet CA-610 inserts not only increased the production of the machine on this job, but actually gave 50% longer life than the comparable cutting materials previously used.

These heavy-duty CA-600 Carmet grades (premium products in performance, *at no premium in price*) have been thoroughly job-proved in the field. They're available to fit *your* steel-cutting requirements . . . *let us arrange a demonstration of their ability to save time and money for you.* Get in touch with your nearest A-L representative or distributor, or address ***Allegheny Ludlum Steel Corporation, Carmet Division, Detroit 20, Michigan.***

For ALL your CARBIDE needs, call

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AL FINE TOOL STEELS SINCE 1854

For the Sake of Argument

Information Executive—a new Profession . . .

By Norman G. Shidle

The exchange of technical information, SAE's main business, is becoming a major function in big companies.

Specialization has separated into many minds the engineering information needed to complete the design of a whole automobile or airplane—or an engine or transmission or any other important vehicle unit. Yet it all has to be coordinated again to accomplish the vehicle design. No longer can the complete knowledge needed lodge in a single human mind.

Once a Mr. Ford designed the Ford car; a Mr. Stout designed a Stout airplane. But not any more. Today's technology is too vast, too fast moving to be encompassed for application by a single man.

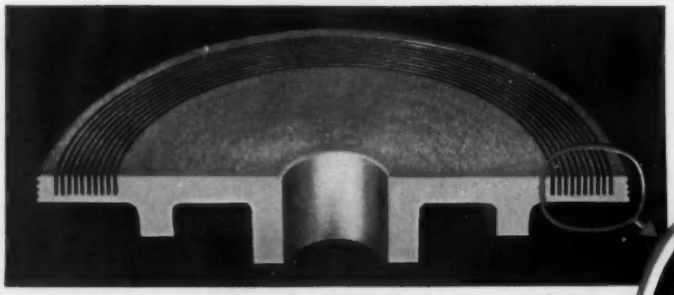
Yet, in more than a few instances the breadth and depth of engineering knowledge in the minds of 1000 engineers has petered out into semi-fruitlessness. It could not be translated, transferred, and coordinated into a single end-product or action.

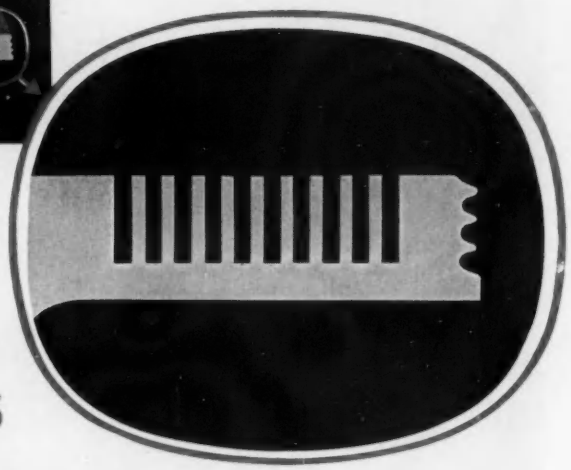
Nowhere in medicine is the presence or lack of "synergism" so apparent as in an engineering operation. In engineering is most noticeable the "cooperative action of discrete agencies such that the total effect is greater than the sum of two or more effects taken independently."

Little wonder that great corporations are economically spending hundreds of thousands of dollars a year for staffs of "information executives."

Their jobs: To facilitate the development, collection, distribution, and application of related technical information within their own companies.

Do Your Castings Require Sharp Corners *Like These?*





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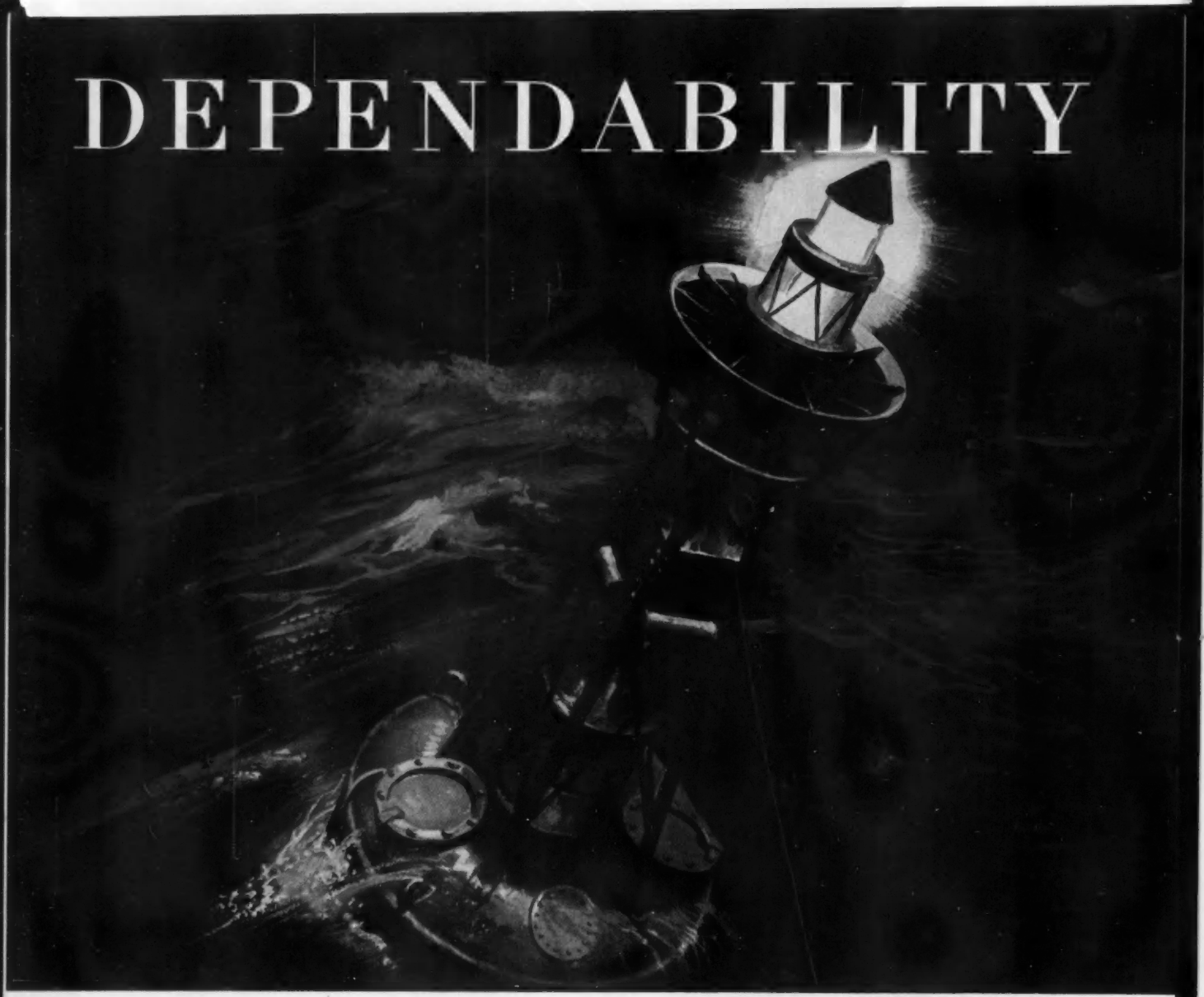

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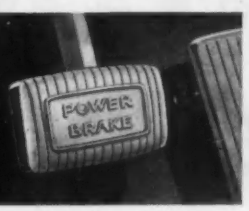

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Summer Meeting Debates Spiced by Overseas Data

MR. PRESIDENT WELCOMES M. LE PRÉSIDENT. SAE President W. Paul Eddy gives the Society's official welcome to Fernand Picard, president of Société des Ingénieurs de l'Automobile—the French counterpart of SAE. (See also p. 18.) M. Picard is director of engineering at Renault.

SAE was host to M. Fernand Picard, president of the Société des Ingénieurs de l'Automobile, at its 1957 Summer Meeting. In addition to paying an official visit, the distinguished French engineer detailed for his American audience what French automobile engineers will be working toward in the next five years. (See pp. 26–28.) In return, he heard at the Meeting's 23 technical sessions the plans, hopes, and dreams of his American confreres.

The overseas flavor of this June 2–7 gathering at Chalfonte-Haddon Hall in Atlantic City was further emphasized by discussion of less-than-10-hp European aircooled engines, of a balanced-pressure precombustion chamber for high-speed diesel engines, and by an SAE Overseas Information Committee report. OIC Chairman C. G. A. Rosen told SAE Council:

> "A new approach to obtaining information from SAE members stationed overseas was agreed upon at yesterday's committee meeting. Committee members will write to selected SAE overseas members suggesting that they may wish to contribute papers that could be presented by title at an SAE meeting. Title presentation, of course, permits them to contribute papers to the SAE literature without coming to this country to present them. If agreeable to this suggestion, they would be requested to send digests. Overseas members whose digests are favorably considered would then be requested to contribute papers for title presentation.
>
> "Proposals to reciprocate by reversing the flow of information so that it goes from this country and Canada overseas are under consideration. These include encouraging more SAE members to present papers at overseas meetings and increasing the number of exchange memberships."

The meeting was outstanding for the size of its attendance (more than 1500); for the success of its chief social function ("An Evening in Paris"); and for the rain and fog (which only infrequently wasn't there). Technical sessions were well attended throughout the week—both in the daytime and in the evening. . . . And a vast amount of work was done by various technical and administrative committees, more than 50 of which were in action.

Partly due to the bad weather, partly to the attractiveness of the technical menu, participation in organized sport and social activities was less than in previous years—except for the ladies.

Current attack on a variety of ground vehicle problems was detailed during the meeting.

Truckers revealed experiences with automatic transmissions and voiced a plea for greater brake capacity. Truck designers were urged to configurations which do not load the rear tires more than the front to produce a truck which has a stable "feel" . . . And a truck turbine was revealed on which fuel costs were said to equal those of a 195-hp, overhead-valve V-8.

Car engineers predicted that continued increases in engine compression ratios will result in—among other things—attainment of constant mechanical efficiency ratio over ranges from 7/1 to 12/1 . . . and percentage improvements in thermal efficiency greater than those of the ideal air cycle.

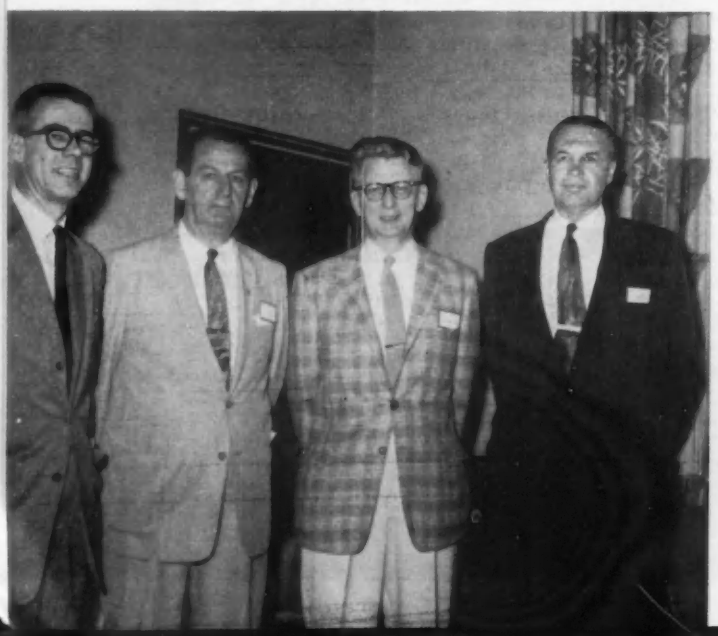
The strongest common wish for passenger-car improvement voiced by 60 SAE-member wives is for more comfort in one way or another. Their second strongest wish, it was reported to the meeting, is for simpler and better operating controls . . . especially for heating and defrosting controls that can be figured out without the aid of a technical

Picard Eddy

ASSISTING IN SAE'S WELCOME to Fernand Picard, president, Société des Ingénieurs de l'Automobile were (left to right): H. L. Brownback, technical counsel to Renault, who has represented SAE at many European gatherings; SAE President W. Paul Eddy; M. Picard; SAE Past-President A. T. Colwell, who read Picard's paper at the Meeting; SAE Past-President C. G. A. Rosen, whose Overseas Information Committee extended the invitation to the distinguished French engineer; and SAE Past-President W. S. James, who was secretary to the session at which Picard and Brownback presented papers.

President Eddy presented to Picard on behalf of SAE a plaque in recognition of Picard's "sponsorship of closer SAE-SIA liaison; his extension of our cherished tradition of technical interchange for mutual benefit; and his comradeship as an eminent figure in engineering achievement."

SECTION GOVERNING BOARD LUNCHEON MEETING was presided over by T. R. Thoren (second from right), who is chairman of the Sections Committee. He emphasized the importance of presenting quality papers at section meetings for the mutual benefit of members and nonmembers. With him are F. B. Lary (left), chairman of the Membership Committee; L. L. Otto (right), chairman of the Student Committee; and L. O. Ray (second from left), chairman of the Placement Committee.



MEETINGS COMMITTEE CHAIRMAN A. O. WILLEY got Council approval of Chalfonte-Haddon Hall as the site and June 5-10 as the dates for the 1960 Summer Meeting. (That's right —1960!)

advisor. Third, they want more storage space.

Tire engineers were heard advocating increased inflation pressures as well as adequate tire sizes to insure good tire life. It's their job, they admit, to design a product to withstand the degrading effects of today's "racing-car" speeds. But they want adequate tire size and increased pressures too.

Reported also was a two-compartment tire, with each compartment having independent pressure. Designers said it can carry a car over 200 miles at 50 mph after a puncture.

Reducing car height has helped to eliminate vibrations which caused certain rear-end noises in 1956, it was reported.

The new low silhouette forced design of a drive line with two propeller shafts, each shorter than the single shaft of 1956. Although roughness and noise still occur at critical speeds, the use of two short shafts has raised these to over 200 mph. So both noise and car operation are satisfactory at customary operating speeds.

The three-joint drive line used with the Hotchkiss suspension has an even greater tendency to set up noises and vibration at certain low speeds. A method utilizing the high-speed digital computer has been devised, however, that allows the design engineer to rapidly establish an optimum three-joint design. If this best design does not prove satisfactory, then this method will reveal the critical areas where improved vibration isolation will provide the basis for satisfactory design.

Greater use of aluminum on passenger cars is predicted by Detroit stylists. Less-expensive tooling, lighter weight, the variety of finishes, and the possibility of color finishes are the reasons given.

Although aluminum is never expected to replace other materials for body trim completely, greater use in conjunction with chrome and stainless steel is predicted. The main objection to aluminum as trim has been its lack of brightness (at a reasonable cost), but stylists now feel that appealing effects can be achieved by using aluminum with the full-bright materials.

Colored aluminum's fade resistance, with the exception of

Announce Progress Steps

PLANNING FOR PROGRESS COMMITTEE reported to SAE Council that it has agreed on enough specific ideas to make desirable preliminary talks with the Constitution Committee.

The report, written by PFP Chairman R. J. S. Pigott (right), said in part:

"After more than a year of fairly intensive study and analysis of the current structure and operations of SAE, our Committee has come to agreement on the rough outlines of an organizational structure that seems better suited to serve the growing and changing needs of SAE members in the future.

"The significant feature of our plan is that we can see the three principal phases of the Society's business operated under three Boards. Although we're not settled on their final names, they are:

"1. A Professional Engineering Board, responsible for the development of technical information and National Meetings for SAE members.

"2. The Technical Board, as it now exists, serving industry in those problems which lend themselves to cooperative technical activity.

"3. A Membership Service Board, to manage the Society's Sections and membership operations.

"We have tried to live through, in advance, the way in which the Society might function under this new organization. We find in our preliminary inspection that this organization has potentials of not only preserving, but greatly enhancing, those three features of SAE which we spotted as all-important early in our discussions. They are: Member Participation, Flexibility, and Continuity.

"In weighing the proposed plan, we feel that we have much to gain over the present organization. And we can't see that we will lose anything of value in our present structure.

"Admittedly, we have many details to work out. What we're planning to do next is to bring in the SAE Constitution Committee to consult and work with us.

"We look forward with much interest and anticipation to this next step, which you might call Phase Two of our operation. We will report to you progress in our Phase Two."

Committeemen in the picture, in addition to Chairman Pigott, are (left to right): **W. K. Creson, SAE President W. Paul Eddy, SAE Past-President G. A. Delaney,** and **Leonard Raymond.** (**B. B. Bachman** and **Harry Chesebrough,** also members of the Committee, were not at the Atlantic City meeting of the group.)

AN EVENING IN PARIS was the major social event of the 1957 SAE Summer Meeting. Here with a member (left) of the Frivolités Françaises troupe which entertained at the party, are the co-chairmen of the event, Sallie and Jack Cole. On the Cole's Committee were Jane and Ralph Albright, Alice and Wayne Coodale, Mel and Bob Hogan, and Marjorie and Jack Splitstone.

gold, is unsatisfactory at the present time. But stylists visualize complete interior color harmony in the future with extensive use of colored aluminum trim and hardware. Exterior opportunities for colored aluminum include side trim, bumper, grille, and window areas. And the brass tube-aluminum fin and all-aluminum radiator are in the not-too-distant future.

Much controversy appeared at the meeting as to the merit of automatic transmissions for truck use.

Some operators reported low average mileage before failure, poor fuel economy, and high maintenance costs with automatics. Conversely, other operators have found them quite satisfactory on these points. Satisfied operators suggest that inadequate driver training, the shortage of qualified mechanics, and poor communications between manufacturer and operator may be responsible for unsatisfactory results.

Both sides agree, however, that—if the manufacturer designs a sound engineering unit, uses the best materials in its manufacture, thoroughly tests the unit, and gives it to the customer on a test basis before merchandizing—the transmission should do the job. Most efficient use, however, requires that the field organization, dealers, and operator's mechanical personnel all be thoroughly familiar with the unit. In addition, the driver must be taught the do's and don't's of proper operation.

Present truck brake capacity, many operators believe, is inadequate to handle the higher downhill speeds resulting from improved roads and more-powerful engines common today. With respect to the newly introduced emergency protection features to protect against service brake deficiencies at vehicle speeds which impose a brake requirement in excess of the capacity of present brakes, it was mentioned that a vehicle descending a grade at 80 mph would still present a serious braking problem.

Designers must provide additional capacity, they believe, and design a brake where linings remain in contact with the brake drum under severe thermal-distortion conditions. Cerametallic and metallic linings provide some hope in this area with their higher permissible operating temperatures. But they, in turn, present drum and tire problems which must be solved.

CHAIRMEN OF MEN'S AND LADIES' GOLF TOURNAMENTS, Mr. and Mrs. E. H. Scott, present J. W. Pilz, winner of the Men's Tournament with an award for his 36-hole game score of 151. Mrs. J. C. Kyle won the Ladies' 18-hole play with a score of 89.

Challenge Coming for the Diesel

Engineers at the Meeting suggested that it may not be too long before the diesel must prove its position as the economy engine in the heavy-duty vehicle field.

First, the diesel no longer enjoys the fuel cost advantage it used to.

In addition, free-piston engines and gas turbines are appearing on the scene. Both have characteristics mighty useful in heavy-duty vehicles, both commercial and military.

Tests of Ford's experimental free-piston engine in a farm tractor (called the Typhoon) are showing very promising results. Similarly, the GM 200-hp regenerative gas turbine has been successfully tested in a heavy-duty Chevrolet truck-tractor (called the Turbo-Titan). Its military possibilities are also being given serious consideration. Some say it comes closer to the "ideal military engine" than any other powerplant.

The diesel industry is well aware of these new developments. It is far on with researches to find ways to improve the already outstanding fuel economy, reliability and longevity of the diesel.

The Ford Typhoon Farm Tractor

The Ford Typhoon tractor with the 160-hp free-piston turbine engine was reported to open new possibilities for better application of power to farm operations. Ideal torque characteristics, ability to use a wide range of fuels, good response, and flexibility could make it an ideal powerplant for the

Continued on page 22

Exhibits at Summer Meeting

FIFTEEN exhibits rounded out the technical sessions at the SAE Summer Meeting.

Expanding use of small aircooled engines was demonstrated by 12 displays. Over 85 present-day uses of these 6-hp-and-under powerplants were cited in a report to Council by Peter Altman (shown at right top with G. E. Buske, left, and P. D. Gilson, right). Altman is special adviser to SAE President Eddy on Small Engines.

SAE has already developed standards on small carburetors, test codes for comparing performance, and safety features. Standard output shafts are near completion and will simplify applying the expected 5,000,000 engines for 1957 to their applications, reported Altman.

Military standardization of ½ to 20 hp engines and European development of small engines were the subjects of two papers presented at the meeting. A production panel is also planned for the 1957 SAE National Farm, Construction and Industrial Machinery Meeting in Milwaukee, stated Altman. Extensive use of diecasting has dropped the cost of mass produced engines. The techniques used will be the basis of the panel meeting.

Altman pointed out the additional need for technical information on other small engines. Programs on small diesels, air- and liquid-cooled engines up to passenger car hp, LPG engines, natural gas engines, and industrial applications should be set up. These would supplement present work on passenger car, truck, turbine, free-piston, and aircraft engines. Such programs should be planned to give maximum exchange of information.

The small engine application exhibits were: concrete power trowel and vibrator by Mall Tool Co.; air compressor by R & D Lab., U.S. Army Engineers; scooter by Hauke Tool & Engineering Co.; garden tractor by Sears, Roebuck & Co.; riding mower by Jacobsen Mfg. Co.; midget racer by Continental Motors Corp.; Air Force heater by American Air Filter Co.; outboard motor by West Bend Aluminum Co.; Quartermaster tent heater by Vogt Bros. Mfg. Co.; generator and power chain saw by Power Products Corp.

The other exhibits (shown at right) were: Cobalt-60 and Iridium-192 radiography using a Picker Isotope X-ray machine; demonstrations of the IBM Digital Computer solving engineering problems; and the Earth satellite.

MODEL OF DETROIT ARSENAL'S NEW ORDANCE LABORATORY is shown here by Major G. A. Tuttle (center) to C. F. Bachle (left), and R. E. Thibodeau (right), a co-author of the paper presented by Tuttle at Bachle's session.

farm tractor. (Further details on this engine are to be found on pp. 44–48 of this issue.)

The GM Turbo-Titan Truck-Tractor

Gas turbine powered vehicles, such as the GM Turbo-Titan, seem in line to compete with the diesel for heavy-duty applications in the near future. Tests show that the gas turbine may well satisfy the big cry for more power for less weight heard from both commercial and military fields. If the GM tests are any criterion, the gas turbine powered vehicle has unusual versatility, simplicity, and ruggedness, in addition to its remarkable performance. (Further details on this engine and its possible applications are given on pp. 30–34 of this issue.)

Diesel Improvements Envisioned

Some of the vast development work to improve the conventional diesel engine was discussed.

In Germany, there have been such developments as the swirl-chamber engine (described at the 1955 Summer Meeting and reported in the September, 1955, SAE Journal, pp. 18–25) and the MWM balanced - pressure precombustion - chamber diesel, which, thanks to its low rate of pressure rise, is especially noteworthy for its:

1. Smooth combustion and low combustion noise.
2. Ability to use a variety of fuels.
3. Excellent cold-starting characteristics.

In this country, the practical aspects of diesel operation are being studied in great detail. Efforts, not yet successful, to predict the economics of truck operation on a theoretical basis were described.

Factors affecting fuel economy are being analyzed to determine which are most important and what can be done to take advantage of them. For example, it was reported that cruise speed and total engine revolutions per miles are prime factors in fuel consumption. Thus, it appears, under some conditions, higher horsepower may require less gear shifting and give better economy, if the total engine revolutions per mile can be reduced.

Matching the engine to the application is another avenue to better fuel economy. In this connection might be mentioned (1) the use of a transmission and axle combination that allows the engine to operate as closely as practicable to its most efficient speed, and (2) the use of utmost care in the selection of accessories, so that they absorb the minimum of power and still do the job required.

Future goals for improvement in the diesel were also envisioned, among them being:

1. Increasing the bmep by forced induction particularly by the more widespread use of turbocharging in the variable-speed, medium-speed applications.
2. Adoption of more efficient engine configurations, such as multibank arrangements.
3. Reduction of size, with the help of higher rotative speed.
4. Improvements in fuel economy through better knowledge of fuel injection and the combustion process, exhaust turbos, and compressors.
5. Reduction of weight through the use of light metals.
6. Improved adaptability through the adoption of the hydrodynamic torque converter.

Small Engines

Design of small, less-than-6-hp engines got more attention at this Meeting than ever before. Special small engines, it was pointed out, have been developed here in United States because no suitable vehicle engines were available for adaptation. In Europe, on the other hand, many such powerplants have been adaptations of motorcycle and small vehicle engines.

Examples of American practice cited at the meeting included a special series of military engines designed to run 1500 hr between overhauls, weigh down to 5 lb/hp, and have maximum parts interchangeability.

New Production Ideas Revealed

"Floturn" is a new chipless method of shaping metal. Metal displacement occurs in a spiral direction parallel to the centerline of the part being formed. The method permits forming parts to close tolerances with a savings in time and labor costs and minimum waste of material.

A new low-cost blanking tool bridges the gap until permanent tool fabrication is completed. Made of plywood, heat-treated steel rule, rubber, glue, and mild steel, this tool blanks up to ¼-in. thicknesses of low-carbon steel. Materials successfully blanked to date include aluminum, magnesium, vanadium, titanium, low and high carbon and stainless steels.

Progress, both achieved and planned, was recorded in use of existing test techniques and design of new ones . . . for American vehicles and the parts and materials of which they are made.

Accelerated testing methods came in for especially searching and critical evaluation. Rubber, aluminum, paint, and automobile engineers exchanged inside-information on the pitfalls as well as the potentials of tests both old and new.

Each let the other in on what to watch out for when evaluating specific results.

Accelerated tests can never take the place of long-term studies in any of these areas, most of the researchers agreed. They warned especially of the

You'll Be Interested to Know . . .

MOHAWK-HUDSON SECTION has added to its elective offices a Vice-Chairman for Albany and a Vice-Chairman for Schenectady. These are the principal areas of the Section's operation.

BALTIMORE SECTION HAS ADDED a Vice-Chairman representing Diesel Engine Activity.

CAMPAIGN FOR EXECUTIVE MEMBERS, led for the Membership Committee by Continental Motors' president **C. J. Reese,** has begun to pay off. More than 5% of the executives Reese first approached by mail applied for membership within 60 days. . . . More than 6% of the nonmembers serving on SAE technical committees have joined since receiving an invitation from 1956 Technical Board Chairman **Robert Kohr.**

APPLICATIONS FOR MEMBERSHIP in SAE received during the last 12 months are about 5% below the same period a year ago, which was one of the Society's best years . . . the Membership Committee reported to Council at its June 6 meeting.

J. T. DYMENT has been named by SAE President **W. Paul Eddy** to serve on the Wright Brothers Board of Award for a term expiring at the end of 1958 to replace **C. L. JOHNSON,** who has resigned. . . . Dyment has also been made Vice-Chairman of the Overseas Information Committee of which **C. G. A. Rosen** is chairman. In March and April of this year, **DYMENT** talked on "The Problems of Jet Transport Operations" to both the Weybridge and London Branches of the Royal Aeronautical Society and on "Engineering of Airlines" to the R.Ae.S. Air Transport course at Oxford University in England.

J. E. ADAMS, vice-president of manufacturing, White Motor Co., has been selected by SAE Council to fill the unexpired term as SAE Vice-President representing Production Activity left vacant by the death of **Dexter S. Kimball** in May. Adams had been Vice-Chairman for Meetings of the Production Activity Committee.

A. O. WILLEY has been named chairman of the SAE Meetings Committee, following the resignation of **E. S. MacPherson. Harry E. Chesebrough** succeeds Willey as vice-chairman, and **S. J. Tompkins** has been named a member of this Committee.

OTHER IMPORTANT APPOINTMENTS approved by Council at its June 6 meeting included: **Frank Fink,** Ryan Aero, to be special adviser to the SAE President on Guided Missiles; **Harry E. Chesebrough** of Chrysler to membership on the Planning for Progress Committee; **Paul Miller** of Ford to the Overseas Information Committee; **J. D. Graham** of International Harvester to the Production Activity Committee; **Vernon Cunningham** of Douglas to the Aircraft Powerplant Activity Committee; **Dr. C. R. Lewis** of Chrysler as SAE representative on the General Committee of the 1958 Nuclear Congress; and **H. J. Ogorzoly** of Esso Research to the Congress' 1958 Working Committee.

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need for knowledge and experience on the part of the designer who trys to interpret the results on specific materials. Accelerated tests can be a big help, they said, to the engineer who really knows what a particular test **doesn't** show. But they can lead astray the unwary.

Even in prototype testing of complete vehicles, it was said, a liability to error arises from "compressing the time schedule and, thereby altering the similarity."

But new, improved methods of accelerated testing were revealed for both materials and component vehicle parts.

One such test is an about-to-be-available substitute for the long-used (and often misused) salt spray test for coated platings. Another is recently developed inertia-wheel testing. This shows what happens inside an engine when it is called upon to accelerate a 4500-lb vehicle 0 to 60 mph in 10 sec.

Noted also among the recently developed test facilities was the automotive laboratory of the Detroit Arsenal. This new plant consists of facilities not already existing in industry . . . and is available for use by industrial firms working on Ordnance contracts. (Its character results from recommendations of an advisory committee of prominent engineers and Ordnance personnel headed by K. T. Keller, Chrysler's erstwhile board chairman.)

MET SECTION KICK-OFF PARTY COMMITTEE signs in, as did 500 other SAE members who attended the Sunday afternoon festivities. Assisting Kick-off Party Chairman S. G. Tilden, Jr. (second from left) were his father, S. G. Tilden (extreme left), C. M. Larson (second from right), and C. E. Chambliss, Jr. (right), past-chairman of the Met Section. M. G. Beard and T. L. Preble also served on the Committee.

At Summer Meeting

The Cabin Safety Provisions Committee approved ARPs: Exits—Air Transport Cabin Emergency; Escape Devices; Emergency Flotation Equipment. Left to right: Vice-Chairman A. M. Salmon, Chairman S. L. Higginbottom, Secretary A. Howard Hasbrook.

A new air-brake time-lag measurer is described by Homer Seale to the Transportation and Maintenance Technical Committee. The instrument meets requirements set up by his Subcommittee.

A report on Hydraulic Control Systems for Automatic Transmission was completed at the Control Subcommittee meeting. Chairman W. R. Rodgers (right) is shown with B. C. Erickson.

Fundamental data on friction material in automotive transmission is the goal of the Friction Subcommttee. Members plan to run round-robin tests in their plants to develop a reliable test method. Left to right: W. J. Eckert, D. F. Greene, T. W. Havely, Chairman G. R. Smith.

Free-piston-engine nomenclature was approved at the Nomenclature Subcommittee meeting. Names of the parts of the engine are defined and illustrated. Work continues on basic terminology of 2-cycle engines. Left to right: Gregory Flynn, Jr., James Kotlin, L. C. Lichty, Carl Maxwell, William Morain, Chairman C. H. Meile, P. H. Schweitzer, R. J. McCrory.

A manual on Fundamentals of Casting Design will be developed by an active ISTC Division as decided on at this Iron and Steel Technical Committee Executive Committee meeting. Left to right: M. W. Dalrymple, G. K. Manning, A. F. Jones, D. E. Krause, V. A. Crosby, V. E. Hense, M. Kosten, W. A. Bachman, L. H. Winkler, J. W. Caum, J. A. Kingsbury.

An improved brake road test procedure is being developed in the Brake Steering Committee. Comparable data for different brake systems is being gathered. Left to right: Chairman R. K. Super, S. C. Tilden, Stephen Johnson, Jr., J. H. Letsinger, G. C. Vahrenhold.

A heavy-duty test code for truck transmission is being developed by the Performance Subcommittee. Leading the work is Chairman H. W. Christenson.

Multipurpose-Type Gear Lubricant designations, helicopter gear lubricant requirements, and transmission and axle lubricant viscosities were acted upon at a meeting of Fuels and Lubricants Subcommittee A. Left to right: Chairman W. A. Wright, R. P. Lewis, M. D. Gjerde.

Completion of a crankcase oil filter test method occurred at the Filter Test Methods Subcommittee Meeting. Similar work on fuel filters was started this year for fuels used in gasoline and diesel injection systems. Left to right: Ted Sauer, G. E. Anderson, R. K. Welch, F. P. Babcock, F. E. Colvin, R. C. Beckett, Secretary F. C. Koch, Acting Chairman S. L. Earle, S. A. Casale, D. Fairchild, R. L. Young, K. E. Humbert, Jr.

What the Next Five Years Hold for

BETTER fuel consumption and lower dead weight to improve performance, rather than audacious novelties, will feature the French car of the coming five years.

The popular model will be reasonably fast and comfortable and carry four to six passengers. Road conditions being what they are, 90 mph will be adequate for large cars, while the top speed of the smaller ones will rise. Speeds of 56–63 mph will be maximum for the most economical.

With the objective of making the smaller car more comfortable, manufacturers will strive to improve suspension and road-holding qualities. The great difference between curb and loaded weights makes some variable-rate solution of suspension a "must." There will also be a drive to silence cars since the frameless construction tends to make them noisier.

Design actually reflects three requirements of the French consumer—low first cost, fuel consumption, and upkeep. Annual operating expenses and amortization for small cars should run between $500 for modest types to $1000 for cars of greater size. First cost can be lowered only through expanding production, which requires huge capital outlay and a certain stability of model. Low fuel consumption means an improvement of existing design, while low upkeep demands the use of proved design techniques.

French requirements, in turn, reflect the expectations of the French economy. The anticipated expansion in population and incomes means more cars. Higher taxation on car ownership and fuel, coupled with difficulties in getting oil supplies and lack of foreign exchange are the unfavorable factors. They mean continuing emphasis on the small car.

Structure

For cars of somewhat less than 1500-cc displacement, common practice will be to place engines at the rear, overhanging the rear wheels as little as possible. This is simple, cheapest to produce, most economical to operate, and gives the smallest overall dimensions and best handling qualities. The problems of weight distribution, engine cooling, and baggage space make it impractical for use with heavy or high-powered engines. For cars of over 1300-cc displacement, the front-wheel drive should retain its present position.

Engines

Octane numbers for regular fuel are now 80, for high-test 90. New refining facilities will probably raise the regular to 89 and high-test to 96 by 1962. The industry hopes these figures will be obtained without forcing an increase in the present tetraethyl lead dosage of 4.5/10,000.

Almost all French cars are equipped with horizontal opposed 2-cyl aircooled engines (425–850 cc), or 4-cyl in-line water-cooled engines (750–2500 cc). The desire for economy of material and manufacture, light weight, overall size, and ease of upkeep have forced manufacturers to give serious study to balancing problems (dynamic balance), vibration, and noise. The satisfactory results and the holding of engines to their present size lead to the belief that there will be no increase in number of cylinders.

The 4-stroke-cycle engine will be used exclusively by the large manufacturers, and layout is unlikely to change except for a possible move toward horizontal opposed cylinders. All mass-produced engines will have overhead valves and a single camshaft in the crankcase. Raising the octane number in available fuel will permit raising compressions ratios from the present 7–7.6/1 to 7.5–8.25/1.

Aircooling, which has made strides in small displacement engines, may be extended to larger engines. Finally, engine speeds will increase slowly, aided by small cylinder bores (the average is 68.5 mm) and the adopting of stroke/bore ratios equal to or less than 1.

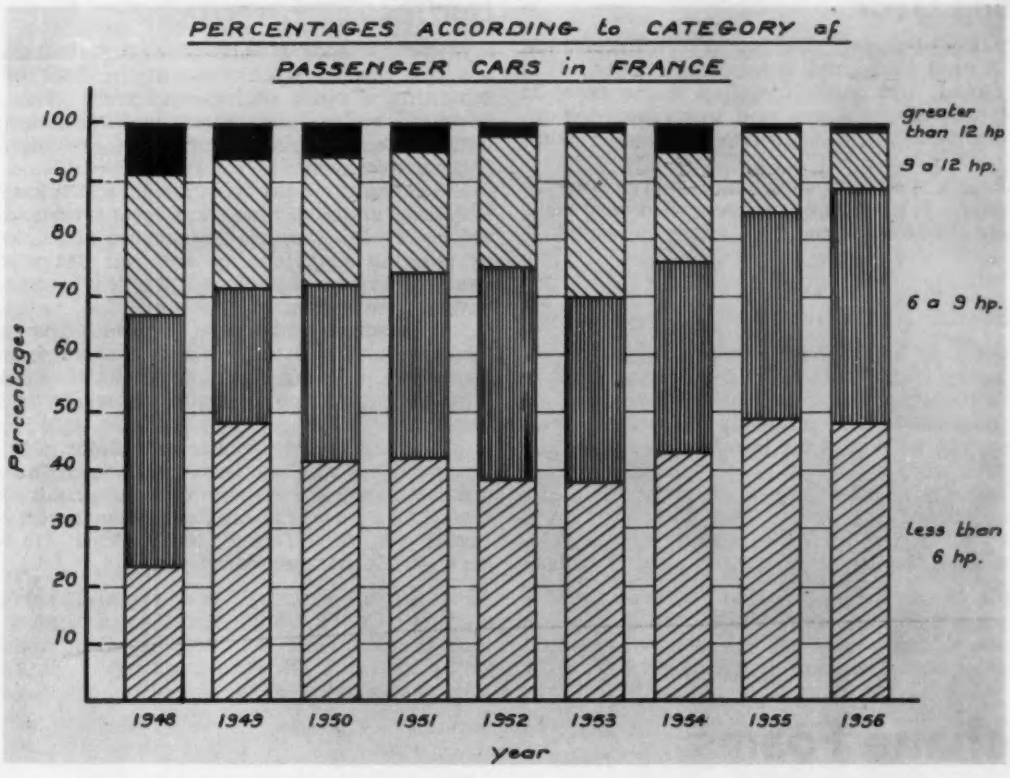
Transmissions

Automatic transmissions face certain technical, economic and psychological barriers. They are invariably complex, therefore expensive, sometimes delicate (electric gearboxes), or have great output losses (hydraulic torque converters), and because of the sport complex are met with disinterest. On the other hand, the automatic clutch is being welcomed by buyers.

By virtue of acceptance and increasing density of traffic we may expect to see automatic clutches, cheaper by reason of increased demand and simpler design, being more widely used in cars of less than 1300 cc, and marked acceptance in the class of car from 1300 to 2000 cc. In this latter class about 50%

French Car Design

Based on paper by **Fernand L. Picard,** Société des Ingénieurs de l'Automobile



PRODUCTION PERCENTAGES based on horsepower show a decline in high-powered cars and rise in lower categories. This reflects French economy, and appears to set the trend for the next five years.

of production should be so equipped within 5 years.

Automatic gearboxes, handicapped by price and lack of known demand, will be limited to cars bordering on or exceeding 2 liters.

Suspensions

The ways to soften the ride are known and three approaches are probable, taking into account the improving of existing devices and the cost angle. These are:

1. Large cars. Trend toward complete pneumatic or oleo-pneumatic suspensions which must have central pumping and distributing centers to give a sufficient output at necessary pressures. These systems will be fitted with a wide variety of corrective controls both static and dynamic to level the vehicle, and a variety of shock absorbers, hydraulic, hydropneumatic or pneumatic with plastoviscous or purely dynamic (damper) action.

2. Medium-sized cars. Mixed suspensions comprising ordinary springs designed for a maximum comfort with car empty and from there on aided by low-pressure pneumatic devices with static leveling

on at least one axle will increase. Installation appears to be relatively simple.

3. Small cars. Rubber or mixed rubber and metal as elastometric springing, aided by plastoviscous control, to permit combinations of sufficient oscillation control and a very low price.

Coupling of the axles or suspension units which can be used in every case either directly (by mechanical interaction) or indirectly (by hydraulic or pneumatic interaction), will demand the same precautions in installation as are used to insure the stability of any vehicle with soft suspension, namely, lowering the center of gravity, locating the roll axis as high as possible, use of antipitch and antiroll stabilizers.

Steering Gear

The rack-and-pinion steering gear will continue to gain ground with small displacement cars. It is simple, cheap, and easily installed if the front is clear of obstacles. Worm and gear mounted on roller bearings will hold its own on medium, or large-sized cars.

Low weight of French cars makes power steering unnecessary. It may make progress with very large cars where the front suspension is heavily loaded.

Brakes

The desire to attain high average speeds in the face of heavy traffic puts an added load on brakes. And the difficulty of using the classic brake drum increases because of the tendency to reduce wheel diameters, use wide rims for low-pressure tires, and shroud the wheels. What is demanded of front wheel brakes now exceeds their capacity. The disc brake is proposed as a solution but its acceptance is doubted. Since the increased speeds are scarcely desirable and the trend is toward light construction where brake problems are not acute, the disc brake is not yet an economical solution.

Electrical Equipment

The 12-v system is gaining steadily over the 6-v system. In the next five years, alternating generators and transistors may replace direct-current generators and voltage regulators. The advantages would be simplification, a weight saving of 30–40%, and better service, and they can be manufactured at an acceptable price. Electronic ignition will probably improve ignition quality, bring about a lower wear rate than that of breaker points, and a possibility of using high compression ratios with greater ease.

Bodies

Frameless body construction, now universal, will progress toward strengthening the floor to permit mounting a wider variety of bodies. This will be accomplished without increasing body weights since lightness and aerodynamic form are essential to inexpensive cars.

Efforts to use light-weight alloys in mass production have ended in an almost total return to welded pressed steel. The widespread use of joining parts by bonding could change this but not within five years. Reinforced polyester plastics have been used in cars produced in small volume.

The medical profession is constantly pushing manufacturers to make their product more comfortable and safer. The construction of seats as well as heating and ventilating systems profit from this.

(Paper, "Previewing French Motor Car Design During the Next Five Years," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Urethane Foams . . .

. . . challenge rubber latex as an automotive seating material. Potential technical and economic advantages stir engineering interest.

Based on paper by **R. H. Walsh,** E. I. du Pont de Nemours & Co.

AUTOMOTIVE engineers are exploring the possibility of using urethane foams for seating material. This relatively new product has already proved its worth in other automotive applications, such as padding for instrument panels and arm rests, and for the acoustical lining of air conditioning ducts.

The urethane foams can be made into products varying from the hardness of a rock to the softness of down, from the resilience of a steel spring to that of a putty. They are self-adherent to wood, fabrics, plastics, and metals. They can be contour-molded or cut readily to any desired shape. As a seating material they should cost less than natural rubber latex for a comparable load-carrying capacity.

It is true that initial tests of the foam as a seating material were, in many instances, disappointing. There was only one type of polyester then available and it was submitted for every type of evaluation, regardless of specific requirements. But those days are past. Today, foams can be formulated to satisfy

specific physical properties, and this warrants their prompt re-evaluation.

Comfort is the test of a seating material. Evaluation of urethane foam can be made by comparing its physical properties of compressive deflection, hysteresis, strain decay, resilience, flex life, and aging with those of natural rubber, since these correlate with performance characteristics.

Load-Carrying Properties

Comparison of load deflection for rubber latex and urethane foam made with polyester resin shows the latter to have an initially high modulus which translates into a crisp, harsh feel. Then follows a plateau where only slight additional weight deflects the foam from 15 to over 40% of its height, to give a sinking-into-the-cushion feeling. Finally, there is a rapid rise in the load required to deflect the foam the last 25 to 35%, which load is only one-half the value of natural rubber foam at 80% deflection. This makes the urethane bottom more easily.

Three ways have been found to overcome these deficiencies and make the urethanes comparable to natural rubber latex. These are (a) use a different type or chemical composition of starting polyol, (b) compound the foam with modifying additives, or (c) cut and shape the foam mechanically to modify its properties. Fig. 1 shows the effects of the second practice.

The original foams made from polyesters had high hysteresis properties and hammocked badly. Improved types made from compounded polyester resin have much better properties. Foams made from polyethers have hysteresis properties comparable with natural rubber and perform well under test.

Foams made from compounded polyethers, Teracol (polyalkylene ether glycol), and polyester resin show less tendency to undergo strain decay than uncompounded urethane foam and have properties similar to natural rubber foam.

Resilience Satisfactory

Resilience tests are used to determine the liveliness of a seating material. The resilience of foam made from polyester resin can be increased substantially by compounding, while those prepared from polyether and Teracol resins are in a class with

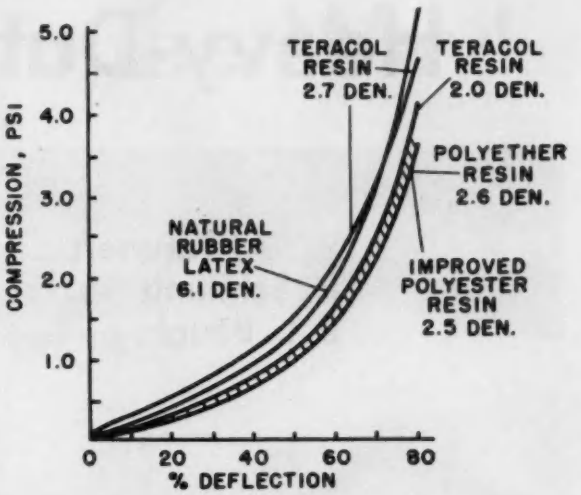


Fig. 1—Adding a small amount of neoprene to a Teracol-based foam or to a polyether based foam, or adding latex to a polyester foaming composition, will give all three foams load-deflection properties comparable to that of natural rubber.

natural rubber although not numerically equal.

Flex tests at 50% deflection showed rubber foams decreasing from 5 to 20% in compression properties after 250,000 flexings, while properly cured urethanes had a compression change ranging from 10 to 35%.

Seating material must age satisfactorily or it is of no practical value. On the basis of accelerated aging tests, it is believed that the improved types of foams should give satisfactory service for at least 15–20 years of normal use.

(Paper, "Automotive Engineering With Urethane Foams" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Excerpts from Discussion by **J. H. Saunders,** Mobay Chemical Co.

WE take strong exception to the author's data and discussion concerning the bottoming of urethane foams. He has compared a very soft grade of polypropylene glycol urethane foam with stiffer grades of Teracol foam and latex rubber foam. Such a comparison is not valid.

We have developed data comparing indentation characteristics of molded cushions from latex rubber and polypropylene glycol foam of similar grades of stiffness. The bottoming characteristics of these polypropylene glycol foam cushions were equal to or better than those of the latex cushions used as controls.

Similarly, automotive topper pad grade foams were compared using molded latex rubber cushions, molded polypropylene glycol foam cushions, polypropylene glycol foam slab stock, and Teracol foam slab stock. The molded polypropylene glycol foam was superior in bottoming characteristics to the latex rubber cushion. The polypropylene glycol foam slab stock without skin was better than the Teracol foam slab stock but was not quite as good as the latex cushion with a skin. The difference is believed to be due primarily to the absence of the skin on the slab stock.

Compression-deflection characteristics were also compared. Again, polypropylene glycol foams were found to be equal to or better than latex foam on bottoming characteristics, and better than the Teracol foam sample.

Heavy-Duty Gas Turbine

Excerpts from paper by

W. A. Turunen, Gas Turbines Department, GM Research Staff
R. Schilling, Research & Development, Chevrolet Engineering Center, GMC
E. L. Baugh, Cleveland Ordnance Plant, Cadillac Motor Car Division, GMC

THE constantly increasing need for more power at less weight for both commercial and military heavy-duty vehicles is encouraging development of gas turbines suitable for these applications. One such is the GM model GT-304 200-hp regenerative gas turbine.

It has already been successfully tested in a heavy-duty Chevrolet truck-tractor, and its military possibilities given a preliminary study.

Turbo-Titan Truck-Tractor

The Turbo-Titan (Fig. 1) was a heavy-duty Chevrolet truck-tractor (model 10413), which incorporated a tandem rear axle, a 6-speed automatic transmsision, and a 3-speed transfer box. The standard engine for this vehicle was a 322 cu in. overhead-valve V-8 rated at 195 hp (gross). This engine was removed and replaced by the 200-hp regenerative gas turbine, model GT-304 (Fig. 2).

The noise level of this installation was very acceptable in every respect. Although slightly noisier at idle, the turbine was significantly quieter under load and the characteristic vibrations and muffler "bark" of the piston engine were completely absent. The exhaust was discharged downward under the cab and posed no problems. It was cool, clean, free of carbon monoxide, and dispersed rapidly.

Performance

The most important advantage shown in tests of this vehicle was a significant gain in performance. In acceleration from 0 to 40 mph, under the normal rating of 50,000 gcw, the Turbo-Titan showed an improvement of 27.5% over the standard installation (Fig. 3). These accelerations were run from standstill with the engine at its normal idle setting. On hill performance the Turbo-Titan showed an improvement in gradeability of 17%. This gain can be considered in several ways. For example, payload could be increased by 10,000 lb while still maintaining better performance than the standard vehicle with rated load.

This improved performance is, to some degree, the result of increased installed horsepower. In large part, however, this resulted from having more useable horsepower available. This concept of useable horsepower is very significant and is a direct result of the torque characteristics of the dual-shaft gas turbine engine (Fig. 4). The torque of this engine is a maximum at stall and decreases iinearly to maximum speed. Thus, a built-in torque converter is provided, without the power loss or cooling requirements normally associated with these units. This favorable torque characteristic results in a broad horsepower curve, allowing the turbine engine to be operated over a wide speed range with a small power loss (Fig. 5). This torque advantage is particularly noticeable on hills and during acceleration, where the piston engine, with its narrower horsepower curve, has a more difficult time staying at peak horsepower and delivering its rated power capacity. Thus, the turbine has more useable horsepower for the same installed horsepower, a fact demonstrated in all tests conducted.

Economy

Fuel economy at various gross weights and speeds was measured at constant speeds on a level road. To make a comparison with a production truck, the gross load of the Turbo-Titan was increased 15,000 lb to maintain more nearly equivalent performance. As there is a difference in fuel costs, the comparison was further made on the basis of ton-miles per dollar of fuel cost. The turbine and gasoline engine fuel costs were estimated as 22.45 and 25.45¢ per gal, respectively.* These costs were based on 1957 mid-continent prices at the wholesale level, to which was added an average of state and Federal taxes totaling 8.82¢ per gal.

The results are shown in Fig. 6. At speeds of 58 mph and above, the turbine engine today operates

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* As the price differential varies throughout the country, the reader may wish to substitute prices to suit his own locality.

Vehicles Are on the Way!

Fig. 1—Turbo-Titan—a heavy-duty Chevrolet truck-tractor fitted with a 200-hp regenerative gas turbine—takes to the road.

Fig. 2—200-hp regenerative gas turbine, model GT-304, installed in truck-tractor.

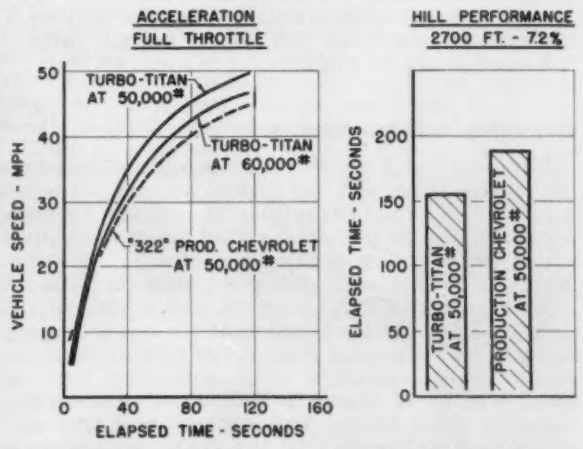


Fig. 3—Turbo-Titan performance compared with that of production unit.

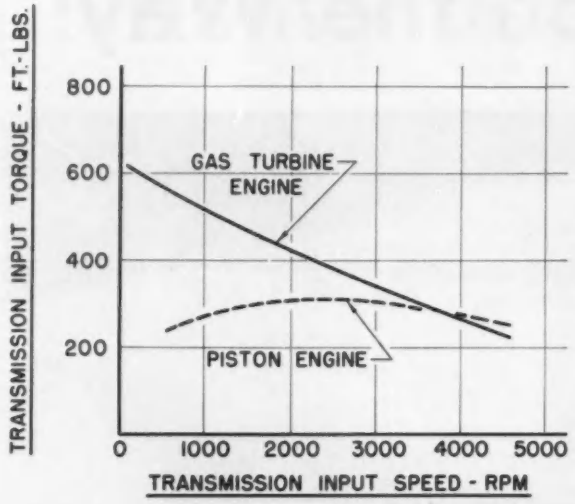


Fig. 4—Torque characteristics of gas turbine engine compared with those of piston engine.

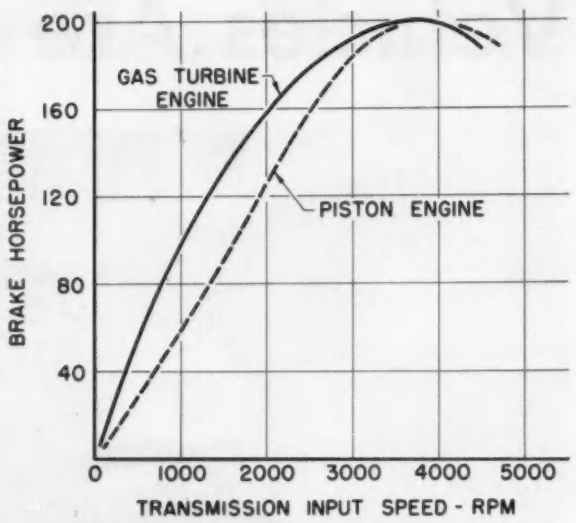


Fig. 5—Horsepower characteristics of gas turbine engine compared with those of piston engine.

with fuel costs that are the same as or less than those of the production piston engine. The upper curve indicates the comparison in the immediate future with further development. This is based on the predicted brake specific fuel consumption, as shown in Fig. 7. Comparative diesel performance was not available. However, the projected fuel consumptions indicate favorable comparisons. In that the gas turbine engine will run equally well on several fuels, from gasoline to diesel No. 2, the operator will have the option of selecting the cheapest fuel available, a consideration not possible with single fuel engines. However, the effect of deposits from leaded gasoline has not yet been evaluated. Fuel economy is always important, but it must be considered in its proper perspective. The additional payload that can be handled by a turbine engine of comparable rating must also be considered. The overall cost balanced against the revenue derived is the final criterion. In this respect the gas turbine indicates strong potential.

Durability and Maintenance

Durability tests are currently being conducted on the Turbo-Titan, but the results are not yet complete. In general, durability of the engine has been excellent, despite the usual run of minor difficulties associated with new engine development. This durability is in line with similar experiences with jet and turboprop aircraft engines and might be expected, as the turbine is inherently a simple engine. Being a true aircooled engine, the turbine does not require bulky radiators, large and noisy fans, or antifreeze, so, of course no difficulties were experienced in these areas. This concept of a true aircooled engine implies that the air to the engine is both the working fluid and the cooling medium. Thus, all of the residual heat of the engine is rejected in the exhaust, and no additional heat rejection system is required.

Oil consumption in the engine has been extremely low. As the oil does not come in contact with combustion products or unburned fuel, it stays clean for long periods. The ignition system is very simple and is required only during starting. Experience has indicated that very little trouble should be encountered here. The fuel control system, which replaces the carburetor, is relatively simple and has operated trouble-free.

Carbon formation or fouling within the regenerator has not been a problem, largely because the

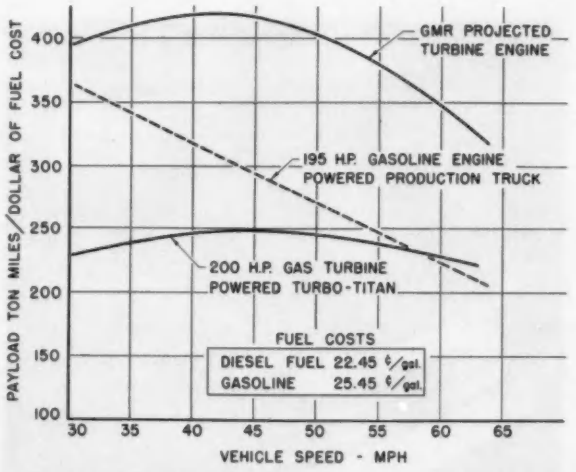


Fig. 6—Road-load steady-state fuel economy of gas turbine units compared with that of production unit.

regenerator is inherently self-cleaning and the exhaust gases are soot-free. The high-speed rotating parts, the compressor and turbines, have shown no distress in spite of the fact that no air cleaners of any type have been used. The present life expectancy of the combustion-chamber liners appears to be less than desirable and work is continuing in this area.

Because of smooth power application and no torsional vibration, transmission and driveline difficulties should be minimized. This is due largely to the rotary, rather than reciprocating, motion of the turbine, which results in a very low vibration level. This low vibration level can be expected to improve materially truck and chassis life and driver comfort.

Since the turbine has considerably fewer parts than the piston engine, and a lower percentage of highly stressed parts, the problems of maintenance and spare parts supply should be simplified. All of our experience to date with turbine engines indicates that durability and reliability of these units will be comparable to or better than those of the piston engine of today.

Military Applications

The ideal military vehicle engine should have the following features:

1. It should have high power for low weight and low volume.

2. It should be aircooled.

3. It should be a true multifuel engine, being capable of burning any fuel currently used or projected for future use by the armed forces, without modification.

4. It should be capable of reliable cold-weather starting with no external assistance or auxiliary powerplants or heaters.

5. It should require absolutely the minimum of maintenance.

6. It should be extremely reliable in operation.

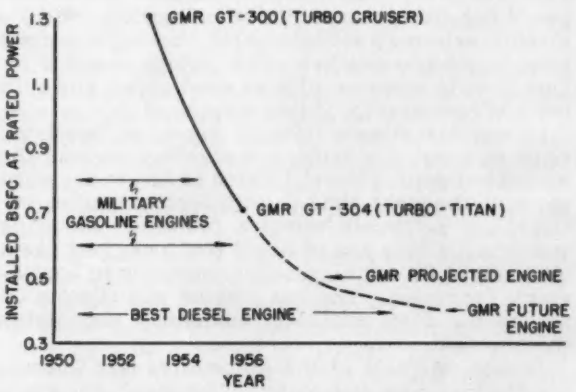


Fig. 7—Brake specific fuel consumption of gas turbine engines compared with that of military and diesel engines.

THE accompanying story is the latest in a series of SAE Journal gas turbine papers authored—or coauthored— by W. A. Turunen, who is in charge of GM's gas turbine developments. The earlier papers are:

1. **"Gas Turbine Possibilities for Cars Analyzed,"**
by W. A. Turunen, SAE Journal, July, 1949, pp. 18-23.

2. **"Turbine Invades Piston's Ground Vehicle Domain,"**
by W. A. Turunen, SAE Journal, July, 1954, pp. 18-27.

3. **"GM Firebird II's Engine,"**
by W. A. Turunen and J. S. Collman, SAE Journal, July, 1956, pp. 48, 52-54.

7. It should require a minimum of transmission as well as minimum driver training.

8. It should be economical to operate from both a fuel and oil standpoint.

9. It should be capable of sitting inoperative for weeks or months at a time without attention and then be capable of immediate operation.

10. It should be quiet and undetectable by the enemy when operating.

There is no known current engine in military vehicles today which meets this ideal. The regenerative gas turbine engine of today, however, comes nearer to meeting these requirements than any other powerplant.

All new combat vehicle designs suffer from one serious design problem, namely weight. The ever-increasing requirements for armor protection, weapon caliber, ammunition storage, operating range, airborne capabilities, and amphibious capabilities all dictate a requirement for absolute minimum weight in the automotive components of the vehicle. This struggle for reducing weight has now progressed to the point where powerplant to vehicle weight ratios in the order of 5% are necessary.

Present reciprocating engines are not meeting this weight specification. Their requirements for air cleaners, mufflers, and extra starting equipment make an already poor weight picture ever worse. The use of a torque converter to improve the torque characteristics of the piston engine adds additional weight and complexity in the transmission, increases fuel consumption, and requires a large transmission cooler and fan. Furthermore, no existing reciprocating engine has an omnivorous fuel characteristic, that is, the ability to operate on a wide range of fuels.

In these same considerations, the gas turbine fares considerably better. In addition to being able to deliver more power per cubic foot of installed space, its transmission requirements can be con-

siderably simplified by the elimination of the torque converter and its associated cooling equipment. At the present time, combat military vehicle transmissions are as big, as heavy, and as complicated as the military engines themselves. With a turbine engine and its built-in torque converter the transmission torque converter can be removed, permitting the large transmission oil cooler and blower to be reduced to a very small package. Instead of the large cooling fan of the aircooled piston engine or the radiator and fan of the water-cooled variety, only a small lube oil cooler is required. In addition, no muffler is required and thus the exhaust system can be simplified. The exhaust is cool as compared to other engines. This is important from an infrared radiation detection standpoint.

The only meaningful comparison of engine types must be on the basis of the completely installed power package, which includes the engine, transmission, and all necessary installed accessories. It is this installed power package concept that shows the real comparison between the gas turbine and conventional engines.

In order to illustrate this point a comparison is made in a military vehicle weighing about 16,000 lb and powered by a 165-hp (net), 6-cyl, aircooled piston engine (Table 1). This engine with oil coolers, airflow space, mufflers, and air cleaners occupies 43.2 cu ft. This is 0.261 cu ft per net installed horsepower. If the General Motors regenerative engine model GT-304 in its present configuration is substituted, a total of 24 cu ft is required. Based on the 200 net installed horsepower, 0.12 cu ft per net installed horsepower is required. This nearly halves the previously necessary engine compartment volume. The space saving can be used for additional fuel capacity and, based on present-day fuel consumption, will result in a vehicle with a turbine engine having four times the range of one powered by the original piston engine. As the efficiencies of turbine components are increased in the near future, the comparison will become even more impressive. The reduction in armor plate required to enclose the engine of reduced volume is also significant. The weight comparison of these two engines is shown in Table 2, and demonstrates, on a "complete powerplant" basis, the advantage of the turbine in this installation.

Table 1—Vehicle Characteristics—Gas Turbine versus Military Piston Engine

	Piston Engine	GT 304
Net Installed Horsepower	165	200
Installed Volume, cu ft	43.2	24
Space/Power Factor, cu ft/hp	0.261	0.120
Fuel	Gasoline only	JP-4 diesel, gasoline, kerosene
Bsfc at Rated Power, lb/bhp-hr	0.60	0.70
Power Package Weight (Engine, Transmission, Accessories)	1775	1310
Weight/Power Factor, lb/hp	10.8	6.5
Range, % of standard	100	400
Transmission	Converter + 2 mechanical ratios	3 mechanical ratios only

Table 2—Weight Comparison—Piston Engine versus Turbine Engine in Hypothetical 16,000-Lb Military Vehicle

	Piston Engine	Turbine Engine
Engine, with Oil	790	710
Transmission, with Oil	610	560
Mufflers and Exhaust	55	15
Air Cleaners	25	10
Winterization Equipment	75	0
Engine Oil Cooler	15	15
Transmission Oil Cooler	25	0
Primer	5	0
Additional Armor	165	0
Total, lb	1775	1310

Much emphasis is being placed on the delivery of military vehicles by air. Without getting into a classified area, it is sufficient to point out that every pound of payload delivered in an airborne maneuver costs airplanes, men, and fuel. Experience indicates that an additional 10 lb of airplane is required for every additional pound of payload. The extra cost of delivering excessively heavy engines, expressed, for example, in gallons of aircraft fuel, may far outweigh any fuel economy advantage these heavy engines may possess over the turbine at the present time. Future comparison will become even more favorable to the turbine engine.

Once delivered by air, the vehicle should require an absolute minimum of support in terms of spare parts, since these, too, must be air delivered. Under some conditions, where time is not available to repair an engine failure, it may be necessary to deliver another complete vehicle. Thus, weight and reliability must necessarily command a special place in the choice of new military engines.

Present and past combat practice has been to idle the main engine continuously in a combat zone. This is believed to be necessary because of the danger of unreliable starting in an emergency. With a turbine, extremely reliable, rapid starting is normal even in subzero weather. The turbine can idle for long periods, however, without overheating and with low fuel consumption if this is required.

In any large-scale military operation involving vehicles, aircraft, marine, and auxiliary engines, the logistics of getting the right kind of fuel to the right place at the right time in sufficient quantities becomes an extremely complex problem. As many will recall, a blitz can of diesel fuel looks just like a blitz can of 80-octane gasoline, resulting in considerable confusion. The gas turbine can operate on any of the fuels available, immensely simplifying this problem.

(Paper, "Aspects of the Automotive Gas Turbine for Military and Commercial Vehicles," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Let's Consider

Ramjet-Turbojet Combinations

for Supersonic Flight

Excerpts from paper by **R. T. De Vault,** Marquardt Aircraft Co.

FOR flight at speeds up to Mach 4 and altitudes up to 90,000 ft, a propulsion system combining small turbojets and ramjets would provide high supersonic performance without sacrifice of subsonic capability. Compared with the use of either type of powerplant alone, it would be light, compact, and efficient:

1. If the turbojet is used by itself it must be so large that VTOL performance is possible. The aircraft will be limited in maximum speed.

2. If the ramjet is used by itself, it will be quite large and it will not provide adequate subsonic performance.

The following analysis will show, briefly, why this is so.

We do not have a typical supersonic aircraft, at present, to base this discussion on so we will have to assume one. The airplane we choose should represent a logical extension of existing practice and should be expected to perform in the normal manner. Let us say, then, that we desire cruising flight at about Mach 3, adequate subsonic performance, and some ability to reach speeds beyond Mach 3.

Assuming a wing loading of about 100 psf, conventional aerodynamic and structural design, we

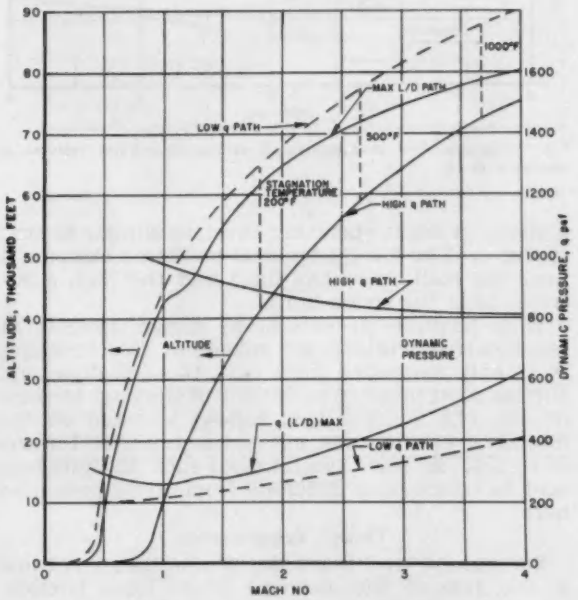


Fig. 1—Altitude-Mach number paths and resulting dynamic pressure.

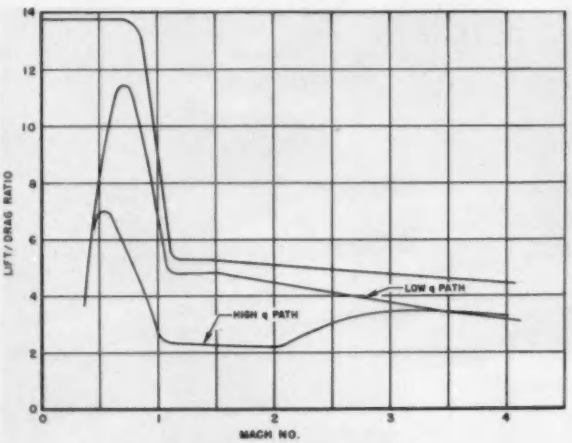


Fig. 2—Assumed maximum L/D of given airplane.

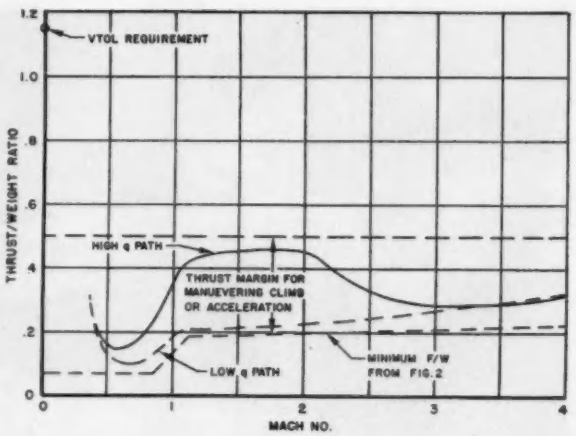


Fig. 3—Thrust-weight ratio required.

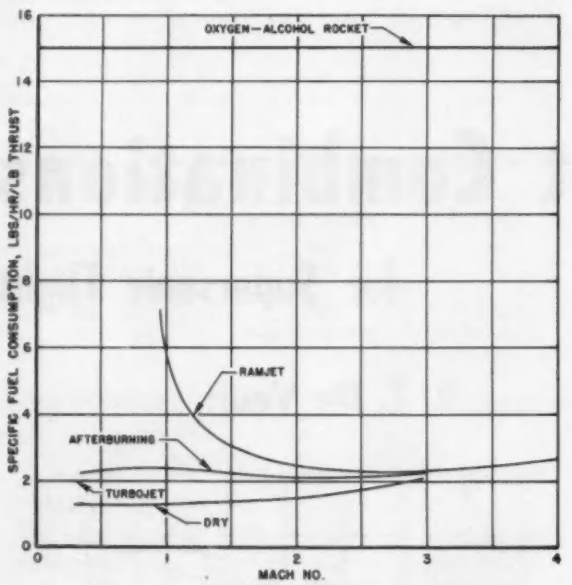


Fig. 4—Specific fuel consumption of various propulsions systems at maximum thrust.

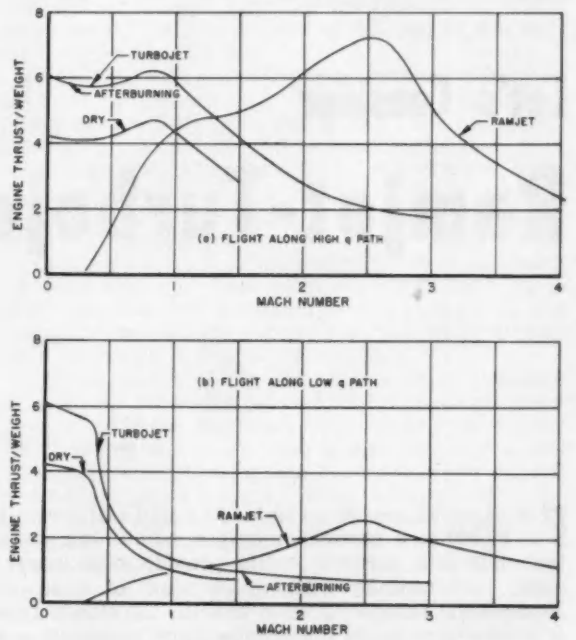


Fig. 5—Engine thrust-weight ratios.

arrive at a flight operating envelope similar to that of Fig. 1. The low q (dynamic pressure) extreme is near the stall or control limit and the high q extreme near the stress limit.

It is possible, of course, to design aircraft or missiles that will operate outside of this envelope. It is only suggested here that this envelope will enclose most interesting designs of the next 10 years or so. The analysis that follows is based on the foregoing assumptions, but can be repeated for any other set. In some special cases such analysis may lead to conclusions different from those presented here.

Thrust Requirements

For steady, level flight the engine thrust is equal to the sum of the airframe drags (skin friction, separation, vortex, and wave.) Thrust in excess of this is required for climb, acceleration, and maneuvering. We will consider the steady, level-flight requirements, bearing in mind the margin required for satisfactory performance.

The maximum value of the lift-drag ratio (L/D) at any Mach number will be determined by the aerodynamic configuration chosen, but must fall within rather narrow limits. A supersonic configuration will not possess a very high value of L/D subsonically, and its supersonic value will be low compared to the familiar subsonic numbers. This is primarily due to the high drag due to lift at supersonic speeds. For a fixed airplane, the L/D in steady, level flight is determined by the altitude and Mach number. Choosing an altitude-Mach number path thus determines the variation of L/D with Mach number and altitude.

Estimated values of maximum L/D and L/D along the low and high q paths of Fig. 1 are presented in Fig. 2 for the assumed airplane.

Having determined the L/D range of interest, it is simple to show the engine thrust performance needed. Inverting Fig. 2 leads to Fig. 3, a plot of the thrust-weight ratio required for steady, level flight. Apparently, a propulsion system capable of producing a thrust equal to one-half the airplane weight would produce satisfactory performance over the entire speed and altitude range. Note that large changes in thrust level are not required within the flight regime. For long-range airplanes, there is a significant weight change due to fuel consumption, so that the thrust requirements may drop considerably in the later stages of the mission.

Thrust Availability

We now have a fair idea of how much thrust we need. In considering the possible sources of thrust it is necessary to inquire into the fuel consumption characteristics of the various engines.

These are presented in Fig. 4, in terms of specific fuel consumption, the fuel used to produce one pound of thrust for one hour. The ramjet data imply variable geometry. The turbojet must use a variable inlet and exit, also, and may need variable stator blades, to allow high Mach number operation.

The high specific fuel consumption of the rocket leads to large and heavy aircraft for long flights. The subsonic ramjet also is a poor long-range powerplant. Above Mach 2, the specific fuel consumption characteristic of the afterburning turbojet and the ramjet become similar, as the turbojet approaches the ramjet type of operation. There is, in fact, reason to believe that the ramjet can produce lower values of specific fuel consumption than the turbojet above Mach 2.5, but the point being made here is that the fuel consumption characteristics are close enough so that other factors must be considered in making an engine selection.

Fig. 5 gives the engine thrust-weight ratios along the selected flight paths.

The technique used here, that of plotting thrust along a flight path, has produced some surprising results, as will be noted from Fig. 5. While the turbojet thrust is high at low speeds, it drops rapidly and reaches very low values along the low q (high-altitude) path. On the other hand, the ramjet thrust rises steadily to about Mach 2.5 and then decreases. Some variation from these data is to be expected with various specific engines. In addition, it seems reasonable to assume that the thrust-weight ratios for the ramjet may be increased markedly with continuing research.

Application of Engines to Airframe

We can now put the performance picture together by selecting an engine type and size and plotting the thrust-weight ratio available over that required. Fig. 6 illustrates two such applications. A turbojet engine weighing 20% of the airplane gross weight and a ramjet engine weighing 10% were selected and their performance superimposed on the plot of Fig. 3 (the thrust-required plot). Only the after-

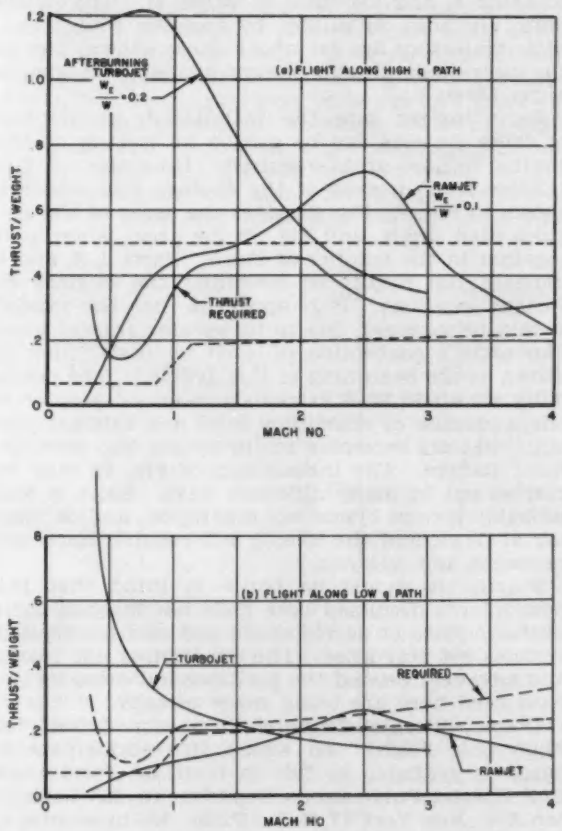


Fig. 6—Application of engines to airframe (separate usage).

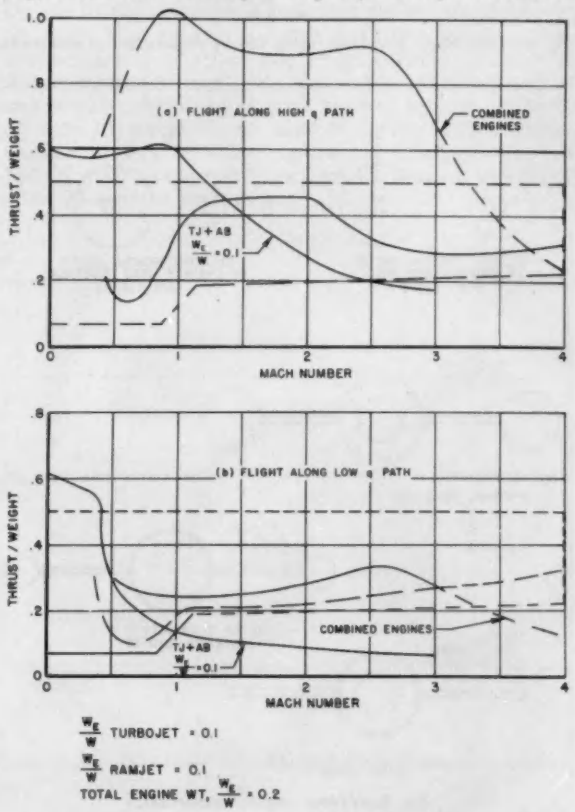


Fig. 7—Application of combined engines.

burning performance of the turbojet has been shown.

First, it will be noted that the turbojet produces enough thrust for VTOL operation. This is a consequence of requiring sufficient thrust for supersonic performance. The engine still is not large enough to fly the airplane along the low q path above Mach 1.5, however, and it cannot operate above its temperature limit at Mach 3.

The ramjet engine cannot fly the airplane at low speeds, of course, and also will not fly the airplane along the low q path except near Mach 2.5.

The ramjet will provide very high performance along the high q path, particularly near Mach 2.5 and will allow speeds up to a Mach 4 at an engine weight of one-half the turbojet weight.

The size of the turbojet would have to be doubled to permit flight along the low q path at Mach 3,

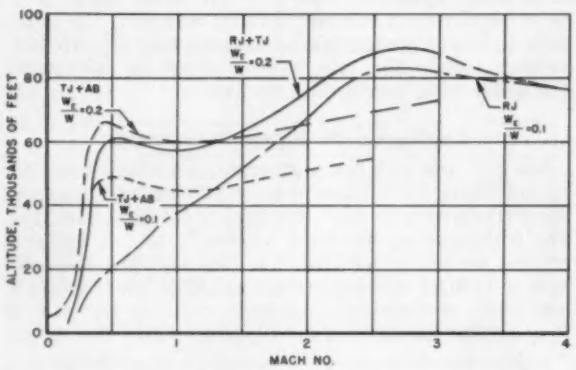


Fig. 8—Level-flight boundaries using various engines and combinations.

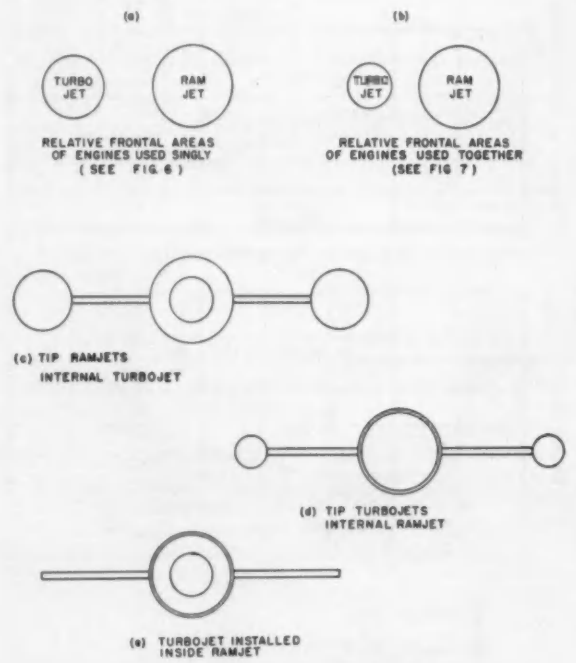

(a)
TURBO JET
RAM JET
RELATIVE FRONTAL AREAS OF ENGINES USED SINGLY (SEE FIG. 6)
(b)
TURBO JET
RAM JET
RELATIVE FRONTAL AREAS OF ENGINES USED TOGETHER (SEE FIG 7)
(c) TIP RAMJETS INTERNAL TURBOJET
(d) TIP TURBOJETS INTERNAL RAMJET
(e) TURBOJET INSTALLED INSIDE RAMJET

Fig. 9—Various engine installations.

while the size of the ramjet would have to be increased 35%.

Now consider the possibility of reducing the size of the turbojet and using the engines together rather than separately. One of the many interesting combinations is illustrated in Fig. 7. Here we have a small turbojet ($W_E/W = 10\%$) and the same weight ramjet ($W_E/W = 10\%$) giving an engine installation of the same weight as the large turbojet originally considered.

The airplane no longer has VTOL performance, but does have enough thrust to take off in the normal manner. Flight along the low q path is now possible up to Mach 3 and the performance available along the high q path is very high, with extreme rates of climb available up to Mach 3.

The performance of the various systems considered is illustrated further by Fig. 8. Here the maximum altitude obtainable in steady, level flight is shown as a function of Mach number.

The small ($W_E/W = 10\%$) turbojet provides modest performance, similar to that obtainable with present-day fighters. Doubling the turbojet size results in an altitude gain of about 15,000 ft and a speed increase to the engine placard limit.

The ramjet, used by itself, provides good performance at high speeds with low weight. Doubling the propulsion system weight by adding a small turbojet gives slightly higher supersonic performance and fills out the subsonic regime.

The combination system will then provide adequate take-off, efficient subsonic cruise, speeds up to Mach 4, and altitudes to 90,000 ft. The maximum altitudes obtainable by zooming into a ballistic trajectory are far above those shown, due to the very high kinetic energy available at speeds above Mach 3.

Some insight into the installation possibilities of these systems can be gained by looking at the engine frontal areas required. Estimates of the relative frontal areas of the engines discussed are shown in Fig. 9. Fig. 9a gives the areas of the engines used singly, and Fig. 9b the areas when used together in the manner of Fig. 7. Parts c, d, and e indicate the results of installing the engines in various locations. It is apparent that the ramjet should be internal, due to its greater frontal area. (An artist's conception of such an installation is shown at the beginning of this article.) The possibility shown in 9e is extremely interesting, since it offers promise of combining inlet and exhaust systems that are becoming major weight and development factors. The installation of Fig. 9e may be carried out in many different ways. Since it will probably involve bypassing, separation, and/or mixing of flows, and the like, it will require much experiment and analysis.

Finally, it should be borne in mind that the powerplants discussed here have not reached their ultimate state of development and new powerplant systems yet may arise. The situation is not frozen and advances beyond the positions indicated by the data used here are being made already.

(Paper, "Ramjet-Turbojet Propulsion System for Supersonic Flight," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Durability Tests . . .

. . . of 2-stroke diesels show exhaust valves are only parts adversely affected by turbocharging.

Excerpts from paper by **J. J. May and V. C. Reddy,** Detroit Diesel Engine Division, General Motors Corp.

TESTS run by Detroit Diesel Engine to determine the effects of turbocharging on the life of its Series 71, 2-stroke diesel reveal the exhaust valves to be the most critical item. The life of production exhaust valves made of a jet blade N-155 alloy was substantially shortened.

This was somewhat confusing to us at first inasmuch as our exhaust temperatures were approximately the same as those normally experienced with nonturbocharged engines. Valve temperature tests were run, using Silcrome No. 1 alloy valves which indicate their operating temperature by reduction in material hardness. These tests showed valve temperatures running considerably higher in the turbocharged engines (Fig. 1).

These higher temperatures may have been due to the increased density of the exhaust gas resulting from the pressure restriction of the turbocharger. The rate of heat transfer to the exhaust valve during the blowdown period is probably greater with the increased density gas.

A number of high-temperature-alloy valves were evaluated in the turbocharged engine before valves of Nimonic 90 material (a nickel base alloy developed for gas turbine blades) were released for production engines. This material gave exceptional life in the engine and may be better and more expensive than necessary. Valves of other materials are under test to determine if a less expensive one can be found that will still have adequate life.

Turbocharging was found to have little effect on the life of main and connecting-rod bearings. Aluminum co-plated, steel-backed bearings had a life considerably in excess of the normal engine overhaul period. Piston-ring and liner life were also not appreciably affected.

Excerpts from discussion by

Hans A. Bohuslav

Miehle-Dexter Supercharger Division, Dexter-Folder Co.

THE authors say that the most critical item in the life of the turbocharged engine appeared to be the exhaust valve. This experience is contrary to practically all other cases of supercharging I know of. Exhaust-valve life is usually improved, when supercharging is adopted. Even Fig. 1 shows a generally lower valve temperature for the supercharged engine. This is contrary to the authors' statement. I believe that this trouble was due to reasons other than supercharging, and the resulting "increased density of the exhaust gas."

Authors' Closure to Discussion

Mr. Bohuslav may have misinterpreted the data shown in Fig. 1, since it includes valve temperatures on both the 2- and 4-valve cylinder heads. The turbocharged engines use only 4-valve heads. A direct comparison shows the valve temperature of the 4-valve head nonturbocharged engine with 80 cu mm injectors to be 1220 F. The turbocharged engine shows a valve operating temperature of 1295 F with 80 cu mm injectors, increasing to 1450 F with 90 cu mm injectors.

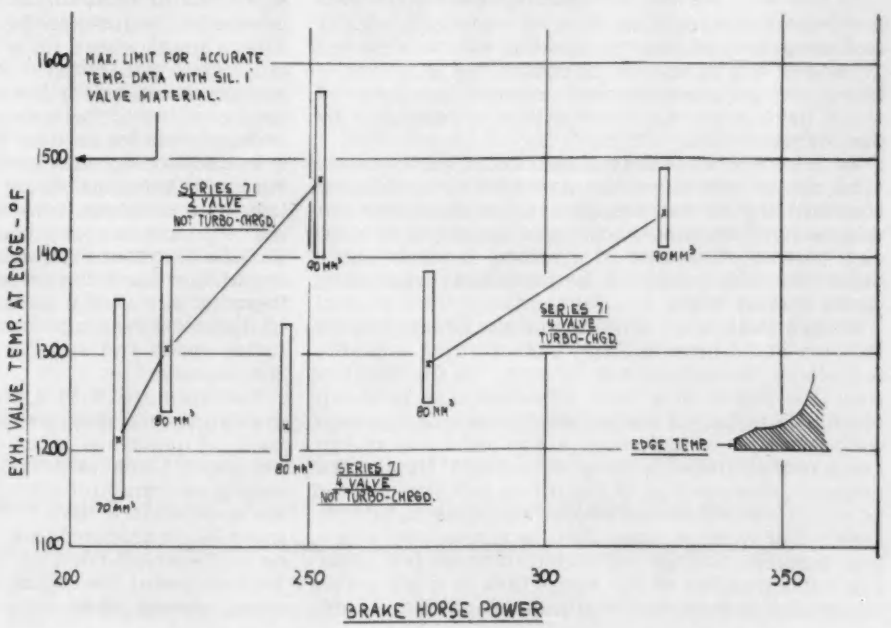


Fig. 1—Comparison of exhaust-valve temperatures on Series 71 engines.

(Paper, "Turbocharging the Series 71 Engine," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Air Force Relies on

Modified Weapon System Procurement Policy

Excerpts from paper by

Major-Gen. David H. Baker, Director of Procurement and Production Wright-Patterson Air Force Base

CURRENT Air Force buying policy combines elements of weapon system procurement methods and government-furnished-equipment procedures.

In the airframe area, the Air Force applies the weapon system concept, in which the prime contractor produces or procures almost all elements, during the development stage . . . and the government-furnished-equipment method of procurement during the production stage.

Regarding missiles, the policy emphasizes the complete weapon system type of procurement throughout both development and production stages. Major exception to this principle in the missile area is in the intercontinental ballistic missile and the intermediate range ballistic missile procurements, where the Air Force has undertaken the integrating responsibility through the medium of a separate contractor.

In this way, we are endeavoring to meet the new problems resulting from the increased complexity and need for complete integration of our weapons . . . and at the same time, to reduce the unfavorable impact a complete weapon system procurement would have on our Air Force and on our national industrial structure.

To illustrate what that impact could be, let us assume that our prime contractors who have complete responsibility for development and production of our weapons system choose to do the entire job in their own plants. The cost of creating in each prime plant the full range of aeronautical capabilities would be very high.

What's more, if all of our prime manufacturers did this, we would have industry concentrated in a very few places throughout our country. In the event of war, this would offer most lucrative targets to our enemy. Further, in the event of an attack, the over concentration would mean a complete loss of our aeronautical industry in a very short time. The present concentration of the prime industry, located as it is for weather and related purposes, is already high. Our policies must tend to discourage, wherever possible, further expansion of these few areas. The concentration of our entire task in a few places would also reduce drastically our capability to expand in the event of a peripheral type war. We experienced this when the Korean war broke out.

Last, but certainly not least, if all of our prime contractors concentrated the complete job in their own plants, the impact on our overall economy would be drastic and we would find the $9 or 10 billion of Air Force annual expenditures concentrated in a very few cities in our country.

Let us assume now that our prime contractors under the complete weapon system of development and procurement utilize the specialized industries rather than producing the entire weapon in their own plants. Even in this situation the costs of our products would rise by approximately 10%. This cost increase would result from buying by several systems contractors of all common items in smaller lots than would be possible if these items were procured directly by one source. Furthermore, these small lots of common items would result in erratic production schedules in a component manufacturer's plant where he is producing for more than one prime contractor. Costs increased for these reasons would be further added to by the paying of profits at both the prime and secondary level in procurement for an item for the Air Force.

In addition to increased cost, this method of procurement certainly would result in a drastic reduction in our efforts towards the standardization of our equipment, particularly for our components. Failure to achieve the maximum in standardization would inevitably result in an increased number of items in our supply system. An increased number of items will result in tremendously increased warehouse space and additional personnel to maintain the stockage.

Furthermore, with a multiplicity of items in the system, higher skills would be required for the overhaul of numerous types of equipment designed to accomplish the same purpose. These continuing supply and maintenance costs amount in total to a great deal more than the initial cost of the equipment being procured and, therefore, have an impact on the over-all costs of operation of the Air Force for the useful life of the weapon, which is in most cases, several years.

To reap the benefits of weapon system procurement without incurring these disadvantages, the Air Force applies the concept, therefore, to missiles and to development stages of manned aircraft—but not to production stages of airframes, where the disadvantages would exert their greatest effect.

This method of operation and this policy have worked out extremely well during the past few years. Today we are developing and producing complete weapon systems and turning over to our combat units weapons which are ready for full combat operation straight from our production lines. We have accomplished this by maintaining our strong overall industrial structure including the specialized sub-system and component industries. Therefore, in effect, while producing complete weapons systems, we have at the same time avoided the major economic mobilization and cost increase problems which are inherent in the complete weapon system concept.

We probably have not accomplished the standardization objectives as effectively as we had originally hoped, principally because we have not been able to monitor too closely the selection and development of various components and sub-systems by prime contractors during the early development stages.

Trend from Airplanes to Missiles

Obviously, the most important single impact on all of our aeronautical business is the gradual reduction in the dollars for the production of aircraft with corresponding increase in dollars for development and production of missiles. With this gradual increase in missile procurement and increased quantities of missiles projected for our production lines in the future, we must begin to shape our policies now for the industrial structure of the missiles future. Our actions at this time will be felt for a long time in the industry. We must endeavor to utilize our existing skills throughout the present aeronautical industry, and we must insure that our weapons work is accomplished in the right places by the best and most highly qualified segments of our industrial structure.

At the present time we find that our increasing missile systems are generating common requirements throughout our aeronautical industrial structure for such things as powerplants, electronics, fuel systems, and controls of various sorts. In many cases we find that where our prime contractors are doing much or all of this work themselves, it is partially because our specialized sub-systems and components industry has not shown enough interest to work aggressively on the many problems involved in missile production. The competition with commercial markets is also a major factor in this area.

This trend, if continued, will gradually generate requirements for new facilities for production and testing which may duplicate some of the existing facilities in the specialized industries. Likewise, we undoubtedly will be duplicating engineering capabilities which are currently available in the specialized sub-systems and component industries at this time. These trends also can lead to the concentration of our complete industrial structure in a few areas of our country with the resultant serious economic and military implications.

The reduction in our aircraft programs and the increase in dollars to be spent on missile production are also developing a new problem which concerns our existing airframe subcontract industry as contrasted to our specialized sub-systems and component industry. As you know, our policy over the past few years has been to require that our prime contractors sub-contract structural parts to existing airframe sources for approximately 40% of the dollar value of the prime contract. This policy, particularly when utilizing competitive procurement procedures has proved most successful in its implementation. It is our intention to retain such subcontract structures with the current programs except in those instances where a program is so small that it obviously is too costly to continue.

However, in some of our new airframe programs where the volume is low and existing prime facilities are only partially utilized, we will find that we cannot afford to continue to enforce this policy to the degree which we have in the past. This does not indicate a change in policy, but more a change in the degree of emphasis in those instances where the government's interests so dictate.

At the same time this trend is occurring in certain aircraft programs, we find that the "airframe" portions of our missiles are relatively simple structures and so small dollar-wise as compared to the total cost of these missiles that it may not be practicable to insist on the high subcontract rate for the "frame" portion of our missiles as we have in the case of manned aircraft.

This change which is gradually taking place throughout our industry should be recognized by that large subcontractor group which has been working on airframes manufacture for our prime contractors.

With regard to our approach to the weapon system concept in the missiles area, we currently have found that where we are gradually getting into full-scale production the specialized component and sub-systems industry is not fully participating in missiles systems.

Both the Air Force and industry must take a hard look at what is happening and where we are going. The Air Force must reconsider its policies for com-

On missiles, the general policy is to have the prime contractor handle all procurement. On manned aircraft, the prime contractor handles all procurement in the development stage. Then in the production stage the government procures and furnishes much of the equipment going into the airframe.

plete systems integration during development and production of missiles and provide a means for closer control, particularly during the development portion of a program to insure that specialized industry functions are not duplicated in our prime plants when they are fully available within the existing aeronautical industry.

In the area of production we must examine closely the desirability of moving to government-furnished-equipment method of procurement in more areas than the very few which we currently have. While I do not expect the degree of government accomplished procurement will equal that which we currently have on aircraft, on the other hand, it would appear that the present degree is not suitable.

However, the major effort in preventing the serious problems which we are gradually introducing into our over-all aeronautical industry structure applies primarily to the strong specialized sub-system and component industries and companies themselves. First, this large and strong segment of our aeronautical industry must recognize that there is a need, more than ever before, for a systems contractor—and even a sub-systems contractor—to integrate the complete weapon system particularly in the development stage. This is a big job which the Air Force cannot undertake itself. Therefore, the specialized industrial group must first sell itself to our prime contractors by fully recognizing the gradual change from aircraft to missile development and production. This will be equally necessary for the remainder of the specialized parts industries which support the efforts of the systems participants, whether at prime or sub-system level. They must adjust their development efforts and potential to missile sub-systems work. Furthermore, in the large missiles, they must recognize that production quantities may not be as great as they have been in the airframe area in the past. They must aggressively establish capabilities in the missile area and particularly they must work closely with the prime contractors to achieve over-all weapon systems integration. Only if this is accomplished, can Air Force policies be directed toward the support of this strong and essential industry in our aeronautical industrial structure.

The success and effectiveness of our efforts are now dependent upon the skill and accomplishment of industry management in carrying out the integrating work which is vital to superior weapons. There is a great deal of the relationship of cooperation and mutual support among the systems participants which cannot be spelled out in the written word. The role of management is to recognize the weapons goal of the procurement methods and to establish those smooth relationships between companies and industries which will permit know-how and assistance to flow between all levels. The areas of agreement and cooperation are many. They involve planning, engineering, design, redesign, testing, reliability, and performance results. There is a challenging job to be done and we must attack it aggressively and without let-up.

If we are to continue to maintain our air superiority we must solve this key management problem of coordination and integration. Our methods are tailored to make this possible.

(Paper, "Air Force's Weapons Systems Concept," on which this abridgment is based, is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

More Comfort for the Crews . . .

. . . may be designed into Mach 2 to Mach 4 aircraft than they are getting in current aircraft operating at the limits of contemporary speeds and altitudes.

Based on paper by **R. B. Crisman and C. L. Forrest,** Bell Aircraft Corp.

THIS may be accomplished by:

- Utilizing a sealed cabin with a stored gas atmosphere (consisting of the most desirable combination of gases) to provide adequate pressurization and respiration, and
- Using an insulated and cooled type of structure to maintain desired temperatures.

In both cases, the crew would be brought closer to the ultimate oft-voiced desire of all airmen . . . to fly the airplane clad only in tee-shirts and shorts.

The sealed cabin with a stored atmosphere is not a completely new idea for solution of both the pressurization and respiration problems. In the X-series of aircraft, the combination of a rocket powerplant and unknown flight regions combined to require just such a cabin. But in the X-1s the large supply of nitrogen aboard to pressurize the propellant tanks was used to pressurize the cabin. (The additional nitrogen required was obtained at a relatively small increase in weight.) The X-1 cockpits were designed to maintain a pressure differential of approximately 3.0 psi above atmospheric. The pilot was equipped with an oxygen mask and a demand oxygen system.

A fundamental fault of this system is that the nitrogen atmosphere was lethal. If either oxygen system or mask failed, the pilot was in serious trouble. This fault was eliminated in the X-2, in which the cockpit was pressurized to the same differential

pressure using liquid air, which served also for respirational purposes.

But both the X-1 and X-2 series were designed when aeromedical art was far behind what it is today. In the sealed cabin today, the following criteria would be used:

In respiration, transfer of oxygen through the membranes of the lungs into the blood is strictly a function of the partial pressure of the oxygen and the vapor pressure of the body fluids. If the oxygen partial pressure in the cabin atmosphere can be maintained at 3.1 psi (sea level value) at all altitudes, respiration will be about the same as at sea level.

Some additional pressurization is required because this value of pressure is not sufficient for some humans. The most satisfactory value, from the standpoint of emergencies, is 5 to 5.5 psia.

Since the oxygen partial pressure is 3.1 psi, an increment of 1.9 to 2.4 psi must be supplied through the use of another gas. It is preferable that this other gas be inert, like nitrogen or helium. Helium looks the more promising because nitrogen is quite soluble in the blood.

Estimates for a pressurized cabin with a gaseous atmosphere satisfying these requirements indicate that they are entirely feasible.

Because of the restriction and discomfort imposed by pressure units, however, these are not considered a satisfactory final answer. Pressurization of the cockpit atmosphere very rapidly becomes impractical as the speeds increase because of the large compressor and power requirements . . . also because of the extremely high temperatures from the high compression ratios.

Some more satisfactory solution must be found.

Temperatures are a problem in Mach 2 to Mach 4 aircraft, even though they are cooler than very early predictions. Temperatures around 1000 F are to be expected in the vicinity of the crew compartment. Such temperatures not only are beyond human tolerance, but approach the extremes of usefulness of many metals.

To get the cooler inside wall desired for both human and design objectives, three areas may be designated in which three different types of structure provide the most efficient method of obtaining strength.

The first region uses different types of unprotected metals—which retain their strength at high temperatures. An aluminum load-carrying structure—protected by insulation—was found best for a second section. The third section uses an aluminum structure, too, but it is cooled as well as insulated.

In this particular "double-wall" structure, the inner skin, which would be the skin surrounding the pilot, is cooled to 200 F by boiling water. Since the boiling point of water drops to between 70 and 80 F at higher altitudes, the crew can be provided with an atmosphere which is not only tolerable, but very comfortable. Thus, the crew is protected at the same time that an efficient design structure is achieved.

(Paper, "Human Factors in the Design of High Performance Aircraft," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Fig. 1—**LIMITATIONS ON VEHICLES** operating between Mach 2 and Mach 4.

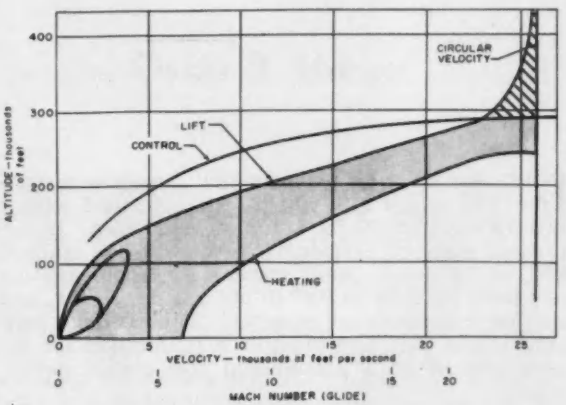
Above the "Control" curve, aerodynamic forces available on control surfaces may be too small to provide adequate vehicle control. To fly above this region, reaction (or jet) controls would probably be necessary.

Above the "Lift" curve, aerodynamic lift cannot be achieved efficiently. In the region below this curve, flight as we experience it today, is possible.

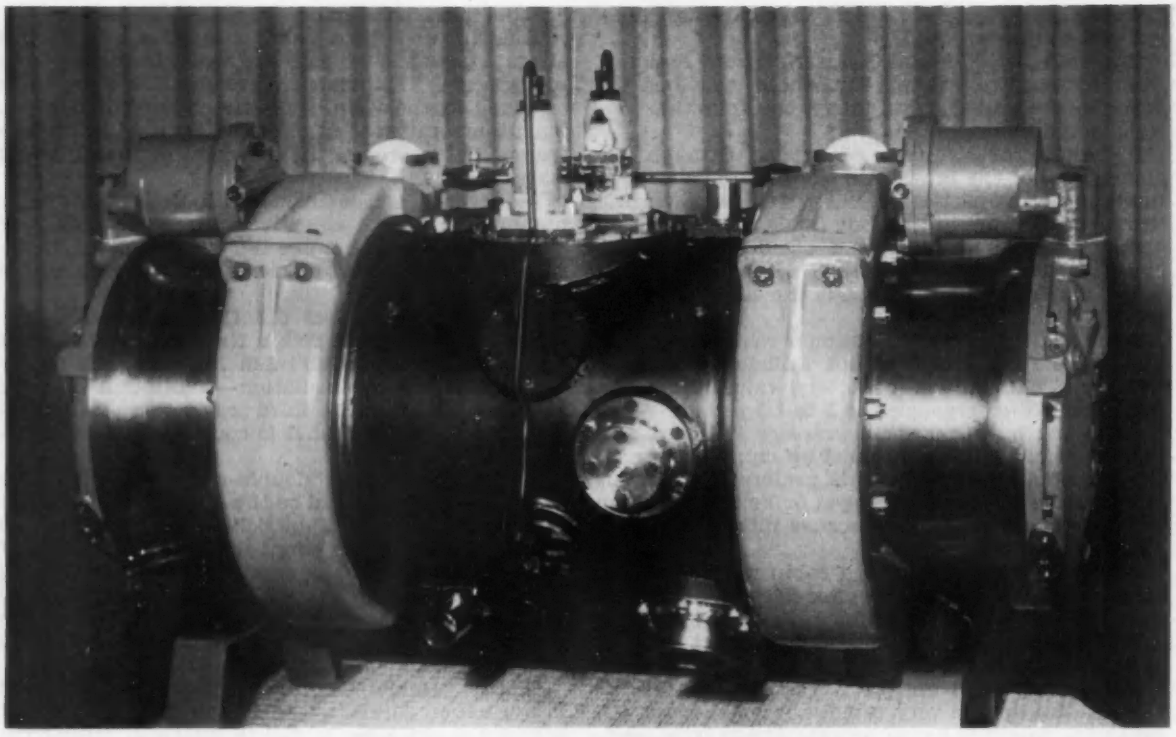
Below the "Heating" curve, the outer surface temperatures of the air frame become so great that the design problems appear to be beyond the present state of the art. This curve corresponds to altitude and speed combinations which will cause a 1600 F outer surface temperature 1 ft behind the leading edge.

The shaded area shows the region where high-performance aircraft may be expected to operate. The loops in the lower left-hand corner indicate the regions in which operational and research aircraft are soon to operate.

Boiling of body fluids takes place at 63,000 ft where the 74 mm of Hg atmospheric pressure corresponds to the vapor pressure of the body fluids of warm-blooded animals. At ambient temperatures lower than this, the body fluids will begin to vaporize.



Cosmic rays are encountered at 120,000 ft.



FORD MODEL 519 GASIFIER with manifolds in place.

Ford Develops the Model

FORD has built an experimental free-piston gasifier, the model 519, which—when teamed with a turbine—is suitable for automotive vehicles. In the present state of development, the 519 has reached 80% of its design-point power. Fuel consumption has been reduced to 0.45 lb per gasifier hp-hr, and further reductions are expected. The gasifier is reliable, starts well, and provides a foundation for the development of a commercial free-piston powerplant.

It uses one pair of synchronizing racks, a design characteristic carried over from Ford's earlier, smaller experimental gasifiers.

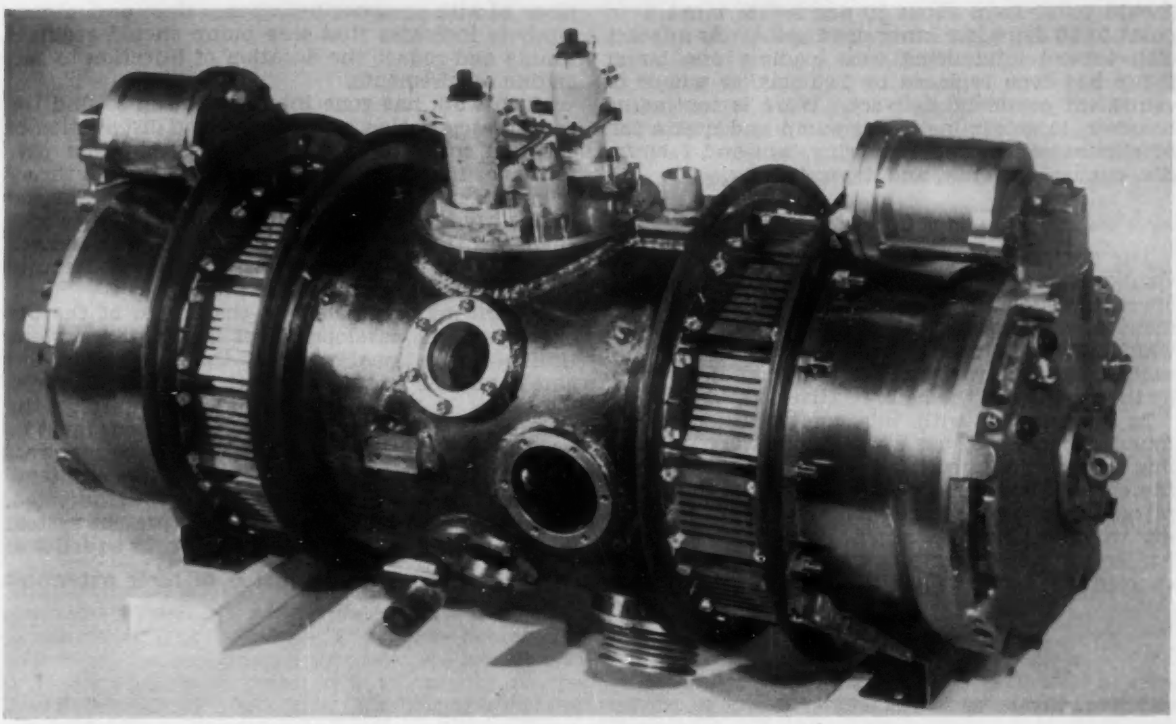
The model 519 has been installed in an experimental farm tractor, which will be described in the next issue of SAE Journal.

The 519 Free Piston Engine Program, begun in November 1955, was a dual effort. One concentrated approach was directed toward determining the thermodynamic relationships for the 519 engine which would establish the proper engine geometry. From this analysis, the bore, stroke, port relationships, and area ratios as well as cyclic frequency were obtained.

The second and concurrent effort was concerned with the mechanical design of the 519 powerplant. From this second effort, synchronizing means, injection pump actuation, valve design, piston design, power cylinder construction, engine materials, and a multitude of small but important design features were determined.

Computer Evaluates Design Changes

During the preliminary phase of the program, performance design calculations were made by hand. These calculations established the basic geometry to which the engine was built. Concurrent with these



REED-TYPE VALVES SHOW after intake manifolds have been removed.

519 Free-Piston Gasifier

Excerpts from paper by **Oscar B. Noren,** Ford Motor Co.

design efforts, a complete and detailed performance analysis was programmed for the IBM 702 computer. Applying this analysis to a number of basic engine configurations, one of which was the 519 engine, the computer vertified the results of the hand calculations and justified the basic engine geometry.

As soon as the 519 gasifier was running, test data were fed into the computer program to reconcile the computer results to the test stand results. This reconciliation involved programming adjustments for actual scavenging efficiency, port losses, valve losses, combustion efficiency, temperatures in the working chambers, and other related factors, so that test data and computer results were essentially the same over the load range of the engine. With the basic analysis locked in with the gasifier test program, it became possible to make changes in engine geometry on the computer with the expectation that the engine would faithfully reproduce the results. This expectation has been realized in practice. With the programming adjustments derived from practice, changes in the performance characteristics of the engine could be evaluated on the computer. This practice saves time and money, and accelerates engine development.

In designing the fuel-injection system, it was necessary to study the limitations imposed by the configuration of the 519 engine. The lack of a finite stroke and clearance volume, and the absence of rotating parts to actuate the injection pumps posed two of the most difficult problems.

In an effort to minimize the shock loading on the cams and followers, linear cams with equivalent cycloidal contours were selected. These cams, mounted on the synchronizing rods, move exactly as the pistons move, creating a timing problem. There is no motion at inner dead point when injection should be taking place. To be satisfactory, injection

should occur from about 30 deg before inner dead point to 10 deg after inner dead point. As another step toward minimizing cam loading, one larger pump has been replaced by two smaller pumps of equivalent combined delivery. Work is continuing however, to determine if one pump and nozzle can be eliminated without impairing cam and follower life, engine efficiency, and dependability.

Various Pumps Tried

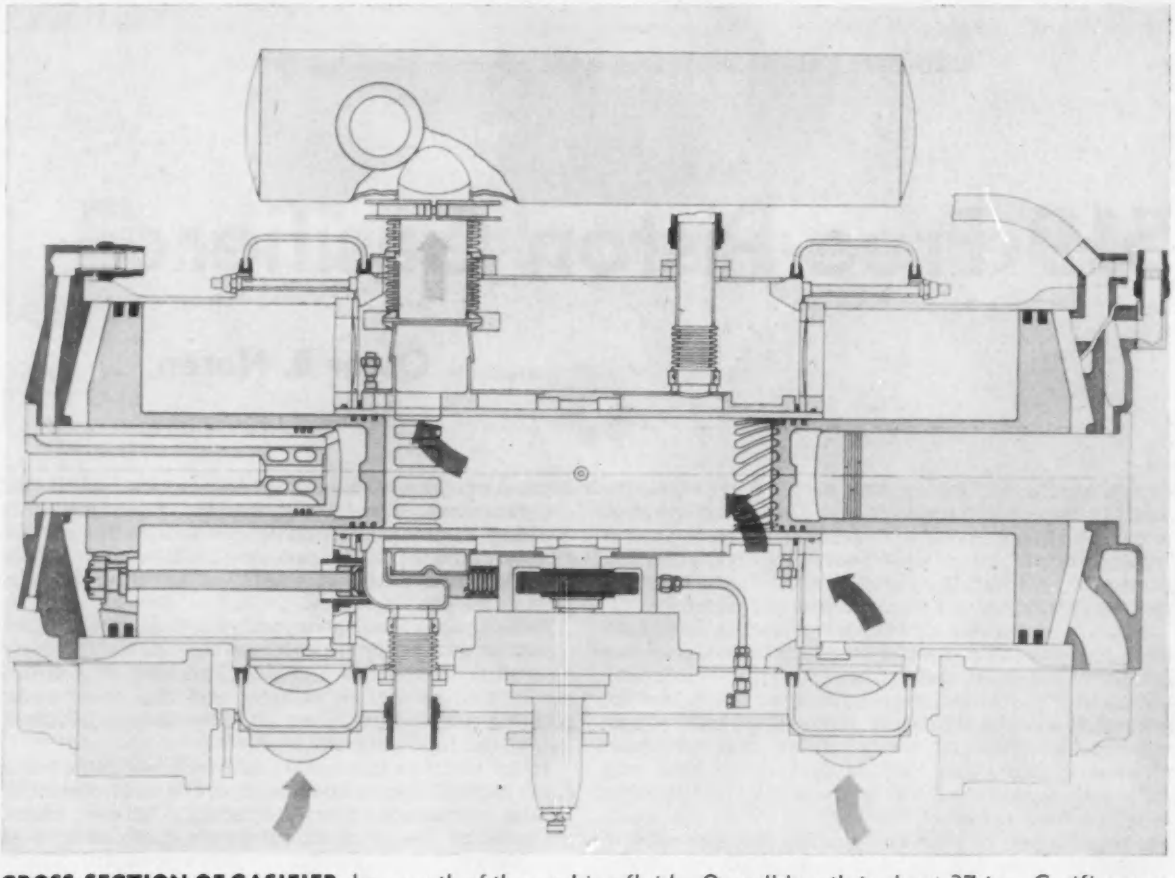
The major difference between pumps is in the configuration of the plungers, which are upper, lower, or double helix. Most of the engine development has been with a lower helix plunger pump which starts delivery at the same cam position in each stroke, and varies the termination of injection by the position of the helix relative to spill port.

In conjunction with this configuration, it was found necessary to use an 84-in. delivery or delay line to time the injection to the desired position in the cycle. Experiments with a pump in which the retraction piston had been removed from the delivery valve, to increase displacement, demonstrated longer injection duration, and it was possible to shorten the discharge line to 20 in. Further work is planned with an upper helix pump since preliminary analysis indicates that this pump should regulate timing and reduce the duration of injection to suit engine requirements.

Much work has gone into attempting to find the correct atomization, penetration, and distribution of the fuel spray to yield optimum combustion performance in the 519 combustion chamber. A three-hole tangential nozzle has resulted in the longest nozzle life, while a seven-hole fan appears to give slightly better engine performance. The search continues for a spray pattern which will improve both performance and nozzle life.

A third major problem in the design of the 519 engine was the development of the starting system. Unlike conventional engines, the free-piston engine cannot be motored through a repetitive cranking cycle. A free-piston engine must start on the first stroke of a starting cycle. The pistons must be brought together with sufficient energy to compress the air in the power cylinder to a pressure and temperature which will ignite the fuel as it is injected. Many systems were tried before the present system was evolved. The starting system works as follows:

1. The pistons are retracted to their outermost



CROSS-SECTION OF GASIFIER shows path of the working fluid. Overall length is about 37 in. Gasifier uses one pair of synchronizer racks. Piston rings used in power cylinder are chrome-plated steel.

position by means of a vacuum pump or an air piston.

2. The starting cans are filled to about 300 psig from an air bottle.
3. The starting valves are triggered by admitting bottle pressure into the trigger chambers.
4. The starting valves open, allowing the stored air to expand into the bounce chamber driving the pistons together.
5. As the pistons travel inwards, the control ports are opened and the excess air in the bounce chamber is allowed to escape.
6. The starting valves close and the engine runs.

Two Functions of Stub Shaft Piston Guides

Stub shaft piston supports on the bounce cylinder head provide a means of supplying cooling oil to the underside of the piston crowns. Oil is directed onto the underside of the piston crowns by a nozzle within the piston guide, and the return flow is scavenged from the guide by a scavenge pump driven by the turbine. This oil is used to cool the power pistons and to lubricate the compressor pistons through a controlled leakage path. The power pistons are lubricated by applying oil directly to the ring belt through four small holes. Oil is supplied to the power pistons by a metering pump, and the total consumption is regulated to 1/200 of full load fuel flow.

The stub shaft piston guides serve a second important function by providing means for stroke control. The schematic diagram of the stroke control system shows the bounce control ports located in the stub shafts. These ports are opened on the inward stroke of the pistons at about the mid-point of the piston travel. The control ports are connected to the surge tank, which is at turbine inlet pressure. At a predetermined point in the bounce chamber cycle, the bounce pressure is adjusted by the action of the control ports. When the bounce volume has been properly selected, in relation to the position of the control ports, automatic stroke control is maintained over the full load range of the engine. An orifice in the connecting passage allows air to flow between the bounce chamber and the surge tank according to the relationship between turbine pressure and the pressure in the bounce chamber while the ports are open.

As the power level is increased, the bounce pressure increases, as does the turbine inlet pressure. This pressure change effectively changes the mass of trapped air in the bounce volume and provides the control medium. The control system is self-compensating and has no moving parts. Throttle response is instantaneous and positive.

Load control of the engine is accomplished by a single link to the compressor inlet throttles, which are mechanically connected to the fuel injection pump racks through an adjustable ratio linkage. This system provides air and fuel metering to the gas generator in predetermined proportions dictated by the gas horsepower required. There is no control connection between the turbine and the gas generator except as provided by the turbine speed governor.

Gasifier Independent of Turbine RPM

The philosophy behind this control system is based on the independence of the gas generator and turbine. Though the pressure-flow relationship does change slightly with turbine speed, this change is negligible. Therefore, aside from governor influence, the gas generator is independent of turbine speed and the gasifier may develop its maximum gas horsepower in conjunction with any speed of the turbine. This contributes to the excellent torque-speed relationship of the powerplant.

When the throttle-rack linkage is properly adjusted, the fuel-air ratio follows a predetermined schedule over the load range of the engine. A primary criterion of proper adjustment is turbine inlet

INBOARD EQUATION

$$\frac{1}{n_1-1}P_1(A+1)(e-x)\left[\left(\frac{e-x}{y}\right)^{n_1-1}-1\right]$$

$$-P_2A\left[\frac{(e+c-y)}{n_2-1}\left\{n_2\pi_1^{\frac{n_2-1}{n_2}}-1\right\}-\pi_1(x+c)\right]$$

$$-\pi_2\left[e-y-g+\frac{g}{n_3-1}\left\{\left(\frac{g}{x}\right)^{n_3-1}-1\right\}\right]-P_3(e-x-y)=0$$

OUTBOARD EQUATION

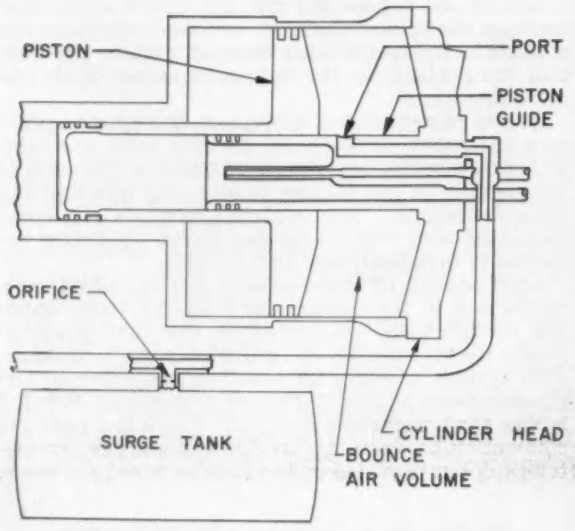
$$\frac{1}{n_1-1}P_1(A+1)(e-x)\left[\left(\frac{e-x}{y}\right)^{n_1-1}-1\right]$$

$$-P_2A\left[\frac{\pi_1(x+c)}{n_2-1}\left\{1-n_2\pi_1^{\frac{1-n_2}{n_2}}\right\}+(e+c-y)\right]$$

$$-\pi_2(e-y-g)-\frac{1}{n_4-1}\left\{g\,\pi_2\left(\frac{g}{x}\right)^{n_3-1}+\frac{R}{C_v}F\right\}\left\{1-\left(\frac{g}{x}\right)^{1-n_4}\right\}$$

$$+P_3(e-x-y)=0$$

ENERGY EQUATIONS for model 519 free-piston gasifier were used in a computer analysis of a number of basic engine configurations.



CONTROL SYSTEM is self-compensating and has no moving parts. Control ports are connected to surge tank, which is at turbine inlet pressure. At a predetermined point in the bounce chamber cycle, the bounce pressure is adjusted by the action of the control ports. When bounce volume has been properly selected in relation to position of control ports, this system maintains automatic stroke control over the full load range.

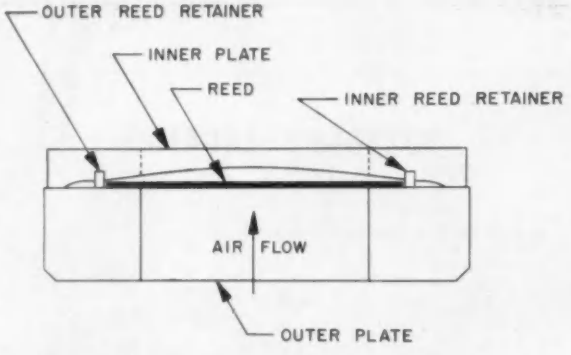
temperature. The better adjustments appear to be those which result in an increase of temperature with load. The turbine inlet temperature range is 600 to 900 F. Rated turbine speed is 43,000 rpm, and, at full load, the turbine inlet pressure is 60 psia.

The present 519 engine has no provision for recirculation. Compressor inlet throttling provides the necessary control and maintains air box temperatures through thermodynamic processes quite similar to recirculation, but with the added advantages of simplicity and directness.

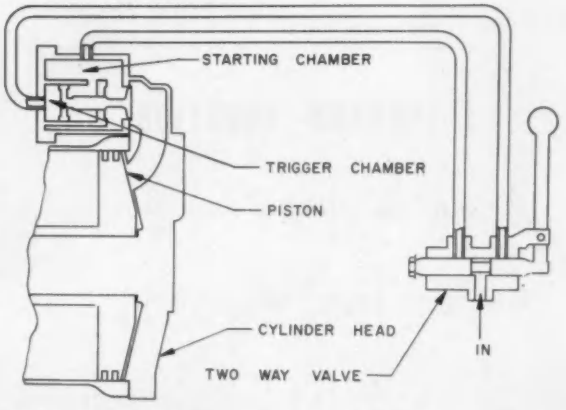
Basically, compressor inlet throttling increases the pressure ratio of the compressor when the power level of the engine is decreased. This provides high air box temperatures to insure compression ignition even at low compression pressures. With reduced air flow to the compressor, total flow losses are small. This control system works well in actual practice, and provides simple, complete, and positive control of the powerplant.

Flow losses from the gasifier to the turbine have been reduced by the use of a flat-plate diffuser in the surge tank inlet, and a rounded edge nozzle in the outlet. Scavenge ports have been materially improved during the engine development program. The basic problem with scavenge ports is the perpetual fight between low flow losses and high combustion chamber turbulence. Fortunately, the 519 power cylinder lends itself well to efficient scavenging. This is primarily due to the favorable length/diameter ratio. The power cylinder has a 3.75-in. bore and is 9.6 in. between the inner edges of the inlet and exhaust ports.

(Paper, "A Free Piston Turbine Tractor Powerplant," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)



COMPRESSOR INLET AND EXHAUST VALVES are reed type. There are 144 intake valves mounted in 24 pads, 12 for each compressor cylinder. Compressor discharge valve plates have 40 valves per cylinder. Valve design chosen has low flow restrictions, offers minimum pressure drop, and has run 1000 hr without failure at conditions approximating full-load engine operation. During the engine development period, there have been no valve failures of any type.



STARTING SYSTEM may be actuated manually as shown here or by a solenoid. Pressure supply for the starting system may be unregulated if a gage is available for the operator. The starting bottle is automatically recharged by the engine, through a tapping valve in the combustion chamber.

6 New Developments to Aid Future Flight

Based on paper by **N. E. Promisel,** Navy Department, Bureau of Aeronautics

Levitation Melting

By this process, a solid can be suspended literally without mechanical support in an electromagnetic field and melted entirely or in part by induced current. High melting, reactive elements such as titanium, zirconium, uranium, and other metals, have been melted in this manner without the physical contamination of a surrounding support.

Extrusion Molding

A machine is now under construction to evaluate the practicability of "extrusion molding" of light alloys. In this process, which lies somewhere between forging and casting, a cast or wrought extrusion billet is forced in a semiplastic state into a split metal mold under conditions of carefully controlled pressure (Fig. 1). The properties anticipated in parts made in this manner approximate those of forgings, but with freedom from anistropy and elimination of many forging shape and alloy restrictions, and with lowered die and operation costs.

Magnesium Alloys

The new major contributor to an improvement in the elevated-temperature properties of magnesium is the addition of 2–3% thorium to previous contents of zinc, zirconium, and manganese.

One such alloy, HK31, contains nominally 3% thorium and 0.7% zirconium and is available in both cast and rolled forms. HZ32 is approximately the same alloy with 2% zinc added. It is for casting use. Another new casting alloy is ZH62A with 6% zinc, 1.6% thorium, 0.7% zirconium. HM31, still somewhat experimental, contains 3% thorium and 1% manganese. It is intended for sheet and extrusions. Fig. 2 shows how these thorium type castings compare in tensile and yield strength, at various temperatures, with the older aluminum-zinc type (AZ92) and cerium types (EZ33 and EK30). Fig. 3 shows the tensile properties after various exposure times at different temperatures. Note that at 400 F the HK31 alloy increases in strength with time, while a number of the other curves remain relatively flat with time.

It is difficult to predict how much further the

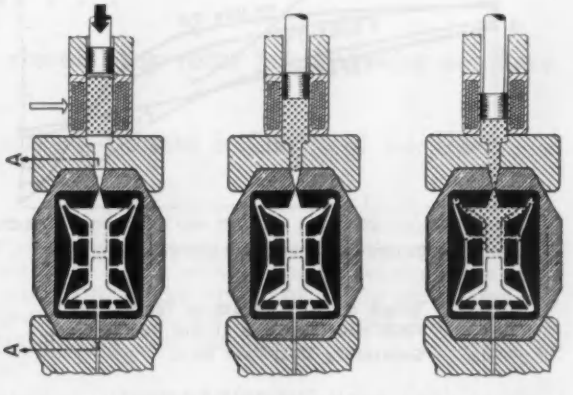


Fig. 1—In this machine for extruding light alloys, a cast or wrought extrusion billet is forced in a semiplastic state into a split metal mold under carefully controlled pressure. Process does away with anistropy and many forging shape and alloy restrictions, also reduces die and operating costs.

strength of magnesium alloys can be increased at elevated temperatures, but it appears that conventional alloying techniques will yield only marginal improvements. Powder metallurgy techniques may permit addition of different types of hardening agents and thus prove more profitable for future investigation.

Iron-Aluminum Alloys

Thermenol, an iron-16% aluminum alloy to which 3% molybdenum has been added to enhance the elevated-temperature strength, has excited considerable interest because there are no critical materials in its composition, because its density is low compared with the corrosion-resisting steels, its strength good to 1000 F and somewhat higher (as shown in Fig. 4), and its resistance to oxidation impressive. It is being considered for applications ranging from compressor blading to combustion chambers for auxiliary gas turbine engines. Forming must be performed warm and in small steps because of its marginal ductility. However, recent work has demonstrated that vacuum arc melting with added grain refiners, followed by controlled heat-treatment, results in a simultaneous doubling of strength and ductility.

Inert-Gas Chamber

The oxidation problem and the need for exploring fabrication and working techniques for molybdenum

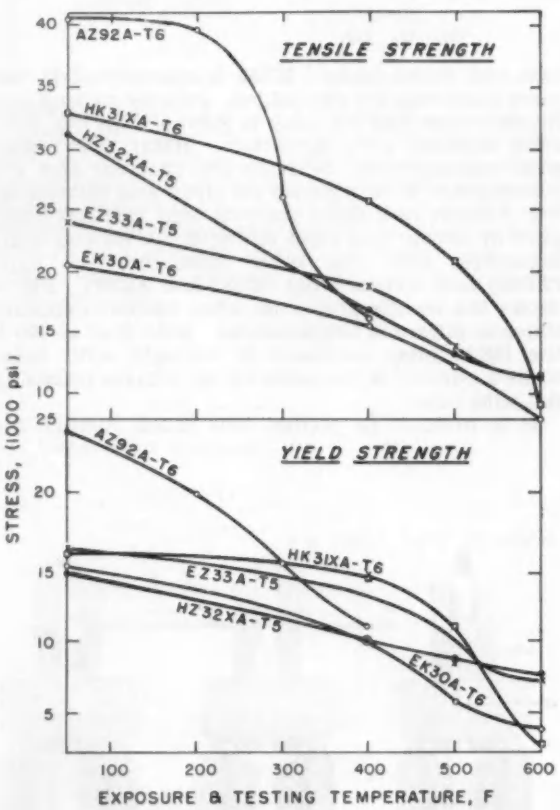


Fig. 2—Addition of thorium to magnesium has improved its properties at elevated temperatures. Here, thorium-type castings are compared in tensile and yield strength with aluminum-zinc- and cerium-type castings.

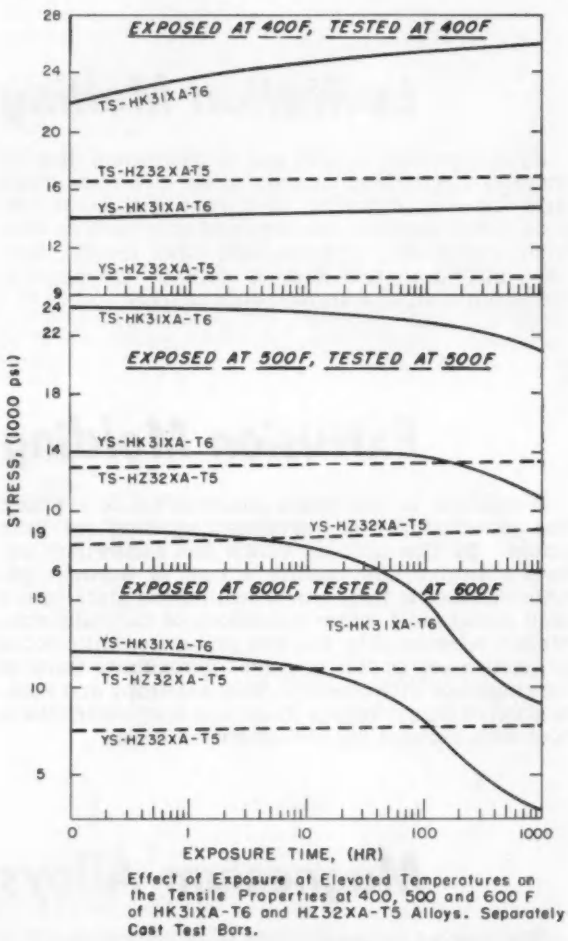


Fig. 3—Comparison of tensile properties of alloys after various exposure times at different temperatures. HK31, the thorium type, shows an increase in strength with time at 400 F, in contrast with no increase for other types.

and other refractory metals at temperatures far higher than ever before has caused the Navy to sponsor facilities at the Universal-Cyclops Steel Corp. for the creation of a large, inert-gas-atmosphere chamber, large enough to contain fabricating equipment such as a rolling mill, forging impactor and welding equipment. At this stage, final details of problems are being resolved, such as control of impurities in the chamber atmosphere to about 100 parts per million, and breathing suits for operating personnel.

Graphite

Among the very refractory elements, graphite is considered as a nozzle material for rockets and ramjets, or for similar applications where extremely high temperature is accompanied by relatively low stress. Its sublimation temperature, though not accurately known, may be in the neighborhood of 7000 F, putting it as high as or above that of any other refractory material. Graphite does not melt, except under simultaneous conditions of temperature higher than sublimation and pressure in excess of 3500 atmospheres. Other valuable properties are its very low density of 2.25 g per cc, its high thermal conductivity of 98 Btu per hr per sq ft per F per ft, its machinability, and high availability. Its resistance to erosion under oxidizing conditions does require improvement, and it can be done in one of several ways:

1. "Alloying" with other refractory metals.
2. Using protective surface layers.
3. Impregnating with materials which reduce porosity, thereby improving immunity to attack.

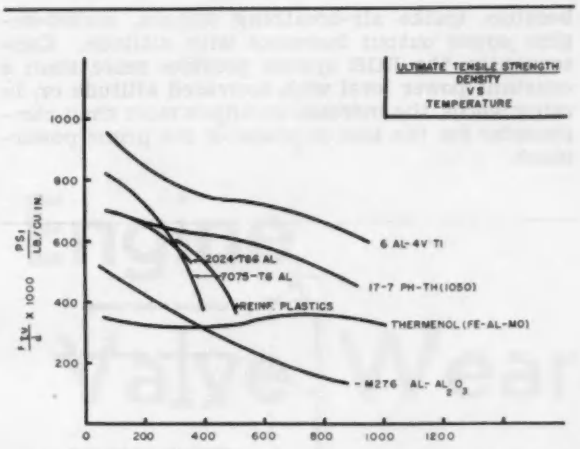


Fig. 4—Thermenol, an iron-16% aluminum alloy with 3% molybdenum, attracts interest because of its excellent strength to temperatures even above 1000 F. It contains no critical materials, its density is low in comparison with corrosion-resistant steels, and it is exceptionally resistant to oxidation.

"Alloying" techniques have produced excellent results. The Stanford Research Institute, working for the Air Force, has produced interesting combinations of silicon, molybdenum, carbon, titanium, and boron. It also has produced graphite impregnated with refractory metal capable of resisting oxidizing atmospheres without dimensional change at torch temperatures well over 4000 F.

(Paper, "Designing Materials for Future Aerial Vehicles," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Rockets-On-Rotor System . . .

. . . deriving power from hydrogen peroxide stored atop rotor hub provides auxiliary power for helicopters.

Based on paper by **Donald S. Chatfield,** Reaction Motors, Inc.

THE ROR powerplant, developed by Reaction Motors under Navy contract, employs tiny rocket engines, each having a nominal 32-lb thrust and weighing approximately 1 lb. The total dry weight of the system as designed for the Sikorsky HRS helicopter (Fig. 1) is 79 lb.

The rocket engine operates on the high-pressure, high-temperature decomposition gases of 90% hydrogen peroxide monopropellant, the propellant supply being adequate for about 6 min of auxiliary power at maximum use. Because the propellant can be decomposed catalytically, there is no need for an ignition system and this, coupled with the rotor-hub-mounted location of the propellant tank, as shown in Fig. 2, makes for inherent simplicity. There are relatively few assemblies and the installation is very clean. The rocket engine is completely submerged in the blade tip except for the nozzle, and the propellant shut-off valve system contains the only moving parts.

Improved Altitude Performance

Probably the most significant improvement derived from the nearly 20% increase in power provided by the system is in altitude performance. At a given aircraft gross weight, this power increase almost doubles the hovering ceiling of the aircraft

because, unlike air-breathing engines, rocket-engine power output increases with altitude. Consequently, the ROR system provides more than a constant power level with increased altitude or, in other words, the increase in output more than compensates for the loss of power of the prime powerplant.

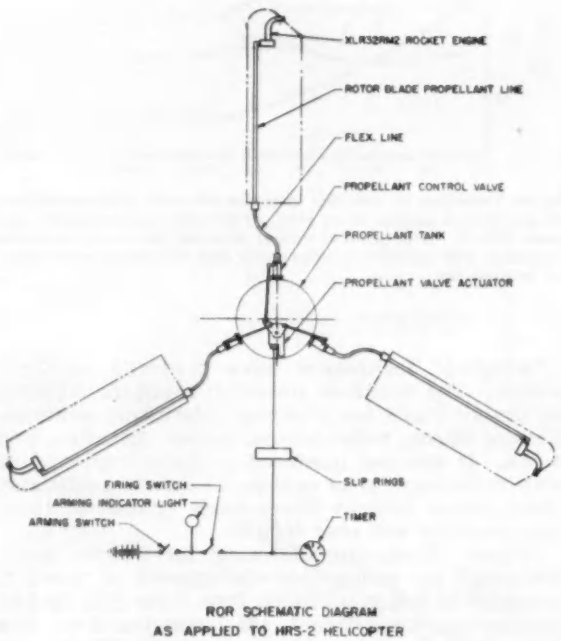


Fig. 1—Rocket-on-rotor (ROR) auxiliary powerplant as designed for Sikorsky HRS helicopter. Note propellant tank above rotor hub and engine submerged in blade tip.

Fig. 2—20% increase in power provided by ROR system, propellant tank of which is seen atop rotor hub on this Sikorsky HRS helicopter, almost doubles the hovering ceiling.

Among other performance advantages obtained with the ROR installation are:

1. An increased payload approaching 100%.

2. An increase in cruising range if the increased payload is used for additional fuel capacity.

3. An increase in vertical take-off rate at normal gross weight.

4. Emergency landing capabilities—power being sufficient to more than double the gliding range and provide good landing control with the main engine inoperative.

The use of the ROR auxiliary power is very flexible. The power can be depended upon continuously for as long as 6 min, or for as short a time as 10 sec. The pilot's control is a simple on-off switch, which can be learned very quickly.

Rocket power is not the most efficient means for producing power, particularly at the relatively low rotor tip speeds of present-day helicopters, but it is attractive for short-duration auxiliary applications because of its high power to dry weight characteristics and its simplicity. If the brute power approach were abandoned, other methods would be available for improving the effectiveness of the ROR system. One of these would be to use the exhaust gases from the rocket engine to improve the lifting ability of the airfoil. In France and England this is being investigated by using a "jet flap" principle to generate very high airfoil lift coefficients.

The jet flap induces supercirculation of air around the airfoil by means of a high-velocity gas stream ejected outward and downward from a narrow slot located on the underside of the trailing edge. In addition to inducing airflow around the airfoil and thereby increasing the lift coefficient, the vertical reaction component of the exhaust jet augments airfoil lift and the combined effect of these two factors is a large increase in airfoil lift that cannot be obtained by any other means.

Although the existing ROR system can be used as emergency power, it was not designed for this purpose and the amount of power available is limited by the requirements for improving flight performance in conjunction with the main engine. Using the Sikorsky HRS as an example, it was determined that rocket engines producing sufficient thrust to maintain cruising flight at maximum allowable aircraft gross weight could still be submerged completely within the envelope dimensions of the rotor blade tip. These engines in conjunction with the existing propellant tank capacity would provide a firing duration of almost 3 min which would be sufficient in most cases for locating and reaching a satisfactory landing area in the event of main engine failure. The dry weight of this auxiliary emergency power system would be about 3 lb heavier than the present booster system because of increased rocket engine size.

(Paper, "Application of Auxiliary Power to Helicopters," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Temperature Affects Engine Valve Wear

Based on paper by **Max J. Tauschek,** Thompson Products, Inc.

MEASUREMENTS of temperatures in operating valves by means of thermally responsive steels have led to the establishment of two basic points:

- Valve temperatures in different model engines vary widely.
- Despite these variations, there is a definite predictable pattern of temperatures over the valve for each type of valve and engine.

Temperature Variations

Variations in temperature for different model engines are shown in Fig. 1. This shows the average valve temperature in passenger-car and heavy truck gasoline engines at the center of the top of the head and at a point on the underhead where the stem joins the underhead radius.

Average passenger-car engines will operate with valve temperatures of about 1200–1300 F. In the average truck engine, these temperatures are 1400–1500 F. Since temperature affects physical properties of the valve alloy, a temperature variation of this magnitude illustrates why valve performance in these two engines differs.

This is one reason why some engines require faced or sodium-cooled valves whereas others will operate perfectly well with plain, unfaced valves. Differences are a function of engine design: the configuration of the cylinder head, the coolant flow, the shape of the exhaust port, and many other factors. This high valve temperature is not a necessary, but rather a usual, price that is paid for good engine output, and careful attention to design detail is required to keep these temperatures in bounds.

Differences between 2- and 4-stroke-cycle exhaust valves show that entirely different valve designs are needed for the two types of engines. There is really only one critical area on the 2-stroke valve at the top of the head. This valve should respond readily to any means of abstracting heat from the head and

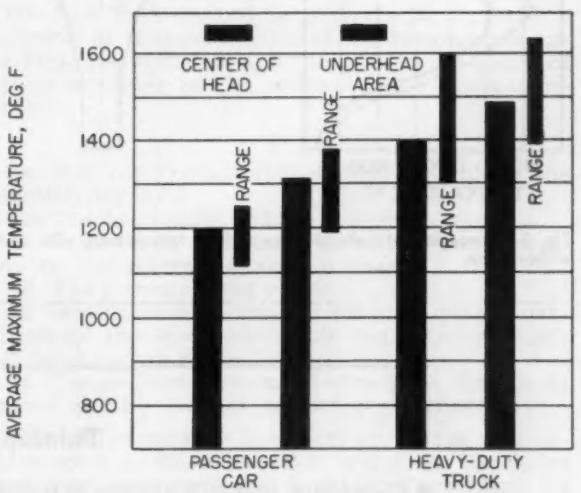


Fig. 1—Average exhaust valve temperatures for passenger cars and heavy-duty trucks.

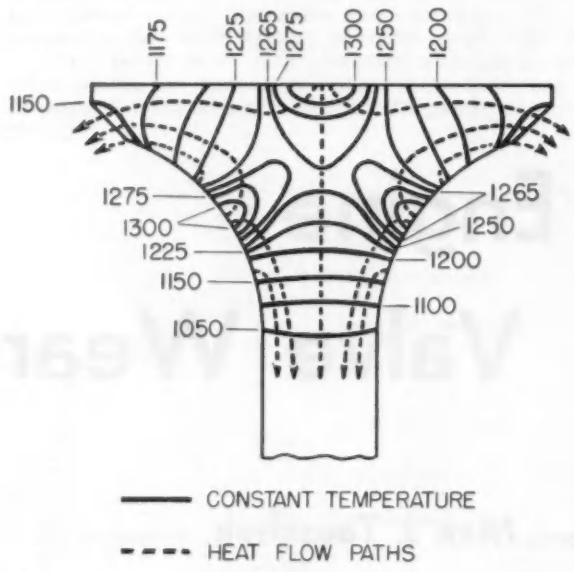


Fig. 2—Heat flow and temperature profiles in typical automotive exhaust valve.

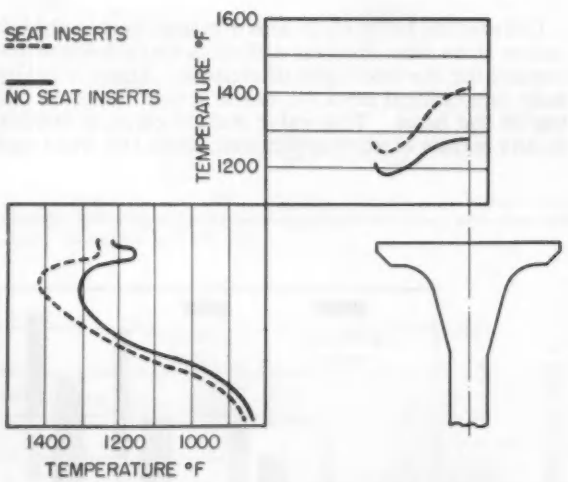


Fig. 3—Comparison of exhaust valve surface temperatures with and without seats.

carrying it down the stem, possibly by using sodium-filled valves.

Temperature Pattern

Heat flow paths and temperature profiles on a typical automotive exhaust valve are shown in Fig. 2. The hot spot in the center of the head is caused by heat input into the valve head from the combustion chamber. Most of this heat is transferred out of the head through the valve seat, which has lower temperature. Another hot spot on the underhead radius corresponds to the point of gas impingement on the valve stem. This results from heat input from the exhaust gases, and this heat is transferred to lower temperature areas at the valve face and down the valve stem. Over one-half of the total heat absorbed by the valve leaves through the valve face.

Some hollow valves, partially filled with sodium, improve cooling of the valve head. When such sodium-cooled valves are used, the heat is transferred by the sodium to the stem in the valve guide area. Sodium cools the hot areas at the top-of-the-head and underhead sections of the valve up to 350 F. Sodium cooling also minimizes the temperature gradient across the top of the head. Hence, sodium-filled valves are particularly advantageous where hot strength of materials and where underhead and top-of-head problems such as underhead erosion, breakage, or face cracking through thermal stresses are encountered.

Sometimes however, sodium-cooled valves incorporate an alloy facing layer to strengthen the effects obtained from using sodium. This layer is intended to withstand corrosion and generally improve burning life.

Inserts can affect the temperature of the valve face. Fig. 3 shows valve temperature profiles run in the same engine with and without seats. Temperatures throughout the valve head, particularly at the face, have been substantially increased. This is due to the impairment in heat transfer that occurs at the junction between the insert seat and the block or head material.

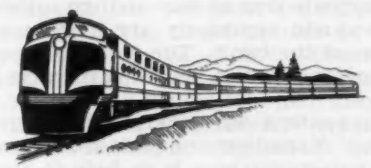
Seat inserts are necessary under certain combinations of engines and fuels that experience a high degree of seat sinkage. Allowance is made for the higher valve operating temperatures by the use of premium valve base steels, sodium cooling, and alloy facings.

(Paper, "Basic Factors Affecting Engine Valves," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Thinking Is Work

■ *Classifying and categorizing is a dilatory tactic employed by scientists and engineers to postpone the effort of thinking.*

—P. H. Pretz



Railroads Find Residuals O. K.

But maintenance costs increase. Discussed here are some of the ways being tried to keep these costs down.

USE of light residual fuels in place of distillates is providing some railroads with substantial savings in diesel operations.

Maintenance costs go up (because of increased wear and deposits, more rapid deterioration of valves and lube oil, filter plugging, and the like), but these costs are more than offset by the lower cost of the residual fuel. (One railroad reported a net fuel savings of $588,000 for 50 locomotives during a 4-year trial period.)

Developments being proposed or actually in use to help keep these maintenance costs down include:

1. Dual-fuel system.
2. Use of additives to reduce deleterious effects of sodium and vanadium content in the fuel.
3. Modified injection equipment.
4. Modified maintenance practices.
5. Use of microscopic examination to control fuel stability and filterability.
6. Bifuel combustion process.

Dual-Fuel System

The dual-fuel system appears to be the most practical way developed so far for using residual fuels in present-day diesel engines, which were designed to operate on distillate fuel. Since it is in the lower throttle positions that the worst trouble is experienced with the residuals, the dual-fuel system allows distillate fuel to be burned at light loads, with automatic switchover to residual above the fourth throttle notch position.

Some railroads are experimenting with blends consisting mainly of residual, with a small per cent of distillate. Others are using a light residual alone. Mostly, though, the final result is a fuel of about 300 SSU viscosity at 100 F. One exception is the Denver & Rio Grand Western Railroad, which is experimenting with a blend of No. 6 residual and No. 2 distillate giving 750 SSU at 100 F. This railroad has also run short-term tests with fuel of 1000 SSU at 100 F, with satisfactory exhaust smoke.

Several automatic dual-fuel systems are available. The New York Central is using the Nemec, with a number of changes because of low-temperature operating requirements and the need to use standard parts available on the railroad. The changes involve:

a. Size and location of fuel lines, particularly the suction fuel lines.
b. The fuel pumps and the fuel pump setup.
c. Removal of fuel line restrictions, particularly in the fuel return and suction lines.
d. The pressure relief valves.
e. Modifications in the fuel filtering system, particularly the incorporation of the standard EMD sintered bronze filters.
f. The electrical system, involving the time delay relays and the location of control switches.

With the system as finally set up, a dead cold engine could be started at 35 F, and when the water temperature reached its normal 165 F, operation on r/d fuel became feasible. This required 1½–2 hr. It should be mentioned, however, that if, for any reason, the heavy fuel system became inoperative, the flick of a switch allowed operation on regular fuel at all throttle positions. The heating capacity

of the dual-fuel system was such that the heavy fuel temperature was only 4–5 F lower than the engine water temperature. As regards heavy fuel flow to the engine, after the water temperature had reached its normal operating level, it was found that a fuel pressure as low as 6 psi to the sintered bronze filters could satisfactorily maintain eighth-notch operation. However, the relief valves are so set that this pressure is normally 20 psi.

Fig. 1 shows the control panel, heavy fuel pumps, and suction filters.

Additives

At present well over half the residual fuels produced entirely from domestic crude does have a low vanadium content. Thus, it is usually possible for the residual user to obtain a fuel satisfactory in this respect.

When this is not the case, so that the fuel has a vanadium content high enough to cause exhaust-valve corrosion and burning, he may find it necessary to resort to additives.

Actually, this sort of trouble is usually caused by high amounts of both sodium and vanadium. The ash that is formed when these are present in sufficient amounts has a fusion point of about 1100 F, which is in the range of valve temperatures. This causes the ash to melt—and in this melted state it is corrosive—the corrosion apparently being worse if *both* sodium and vanadium are present. (At higher temperatures—above 1300 F—there is some evidence to indicate that at least sodium sulfate and vanadium pentoxid separately are more corrosive than mixtures of the two.) The fused ash can also stick to the exhaust valves, resulting in valve burning.

The sodium content can generally be reduced by water washing. Vanadium compounds are insoluble in water, though, so washing is no help in reducing vanadium content. Moreover, it appears that no refining process has been developed that will economically effect a significant reduction in the vanadium content of residual fuel oils.

The answer to this problem lies in another direction, for it has been found that the addition of calcium or magnesium significantly reduces the corrosion and slag-forming tendencies of high-vanadium fuels. The idea is to have two to four times is much calcium or magnesium as vanadium present in the fuel, as this raises the fusion point of the ash to 1800–2000 F. Deposits on metal parts are generally reduced since the ash may not be fused when it contacts the metal. Also, the corrosion is reduced to less than 10% of that occurring with the untreated fuel. This may be due to the fact that the ash is not fused when it contacts the metal, or it may be due to some chemical neutralizing action of the calcium or magnesium salts.

Calcium and magnesium may be added as oil-

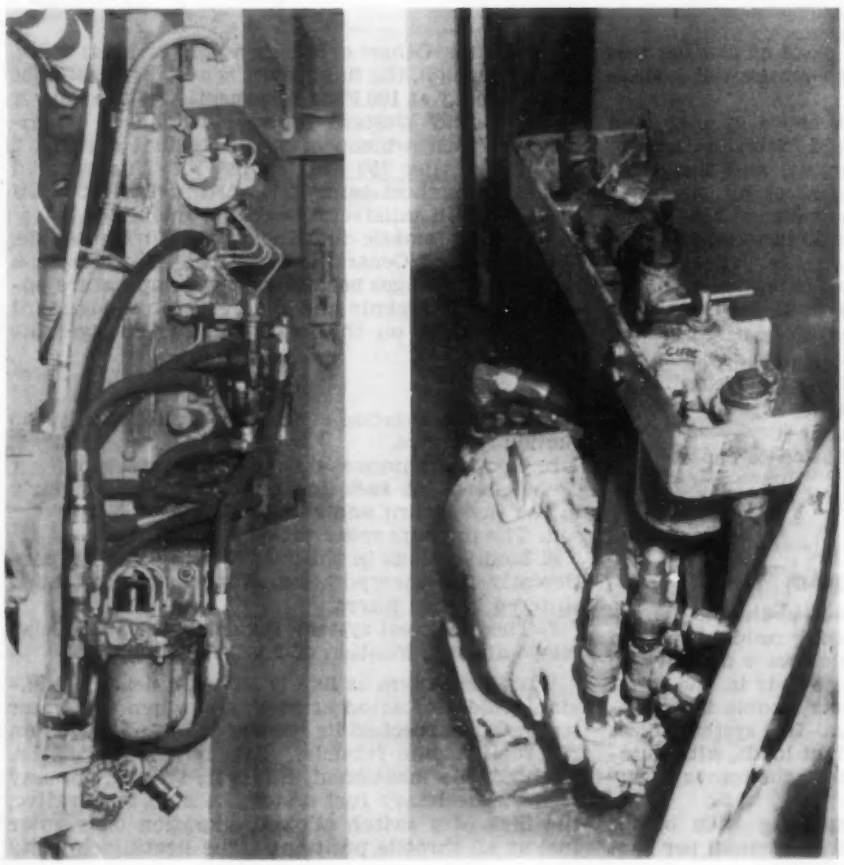


Fig. 1—Dual-fuel system installation showing (left) control panel and (right) fuel pump and suction filters.

soluble compounds, as aqueous solutions, or as finely divided solids. Oil-soluble calcium and magnesium naphthenates or sulfonates may be added to the fuel oil or formed in the residuum during processing of certain crudes. This could be done at the refinery but involves segregation of the crudes and the finished fuel oils and would probably be rather expensive. Calcium and magnesium may also be injected at the time of firing in the form of aqueous solutions of calcium chloride or magnesium sulfate. Also, calcium or magnesium may be injected at the time of burning in the form of a finely divided solid. Dolomite, a naturally occurring mixed calcium and magnesium carbonate, has been used with good results in this manner. However, for use in residual fuels proposed for diesel engines only the oil-soluble calcium and magnesium additives should be considered.

Modifying Injection Equipment

One component that looks as if it may need modifying is the injection equipment. For example, in one test heavy piston crown deposits were experienced with a residual-distillate blend. The pattern of deposits indicated that there may have been direct impingement of the fuel. It was reasoned that this trouble could be avoided if the injector were modified to give a better spray pattern.

The matter is far from clear, though. Other researchers explored various changes in injector spray tip orifice diameter, number, and spray angle in combination with combustion chambers that provided increased cylinder air turbulence. They concluded that, thus far, the standard spray tip drilling has been most satisfactory. They observed no adverse effect on the unit injector plunger and bushing assembly as a result of operating with the more viscous fuels. Stress in the fuel injector rocker arm was found to be only 5–8% greater than when operating on No. 2 diesel fuel at rated engine output conditions.

However, after an injection change to improve atomization of the fuel spray, they found improved low-speed performance with heavy fuel blends. Prolonged idling of 12-hr duration was also achieved with a negligible change in fuel rate. The formation of carbon deposits on injector spray tips at low engine speed was also reduced but not completely eliminated.

Modified Maintenance Procedures

When the lower-quality residual fuel is used, increased maintenance costs must be expected. More extensive deposits, increased wear, more rapid lube oil deterioration must be taken into account in the maintenance program, so as to minimize their effects. This means, in general:

1. Reducing overhaul periods.
2. Changing lubricating oil more often or using a better grade of oil.
3. Changing the fuel filter more frequently or going to centrifuging.

Overhauls—Probably the most serious trouble has come from corroded or burned out exhaust valves

The Names Behind the Story

THIS report on the use of heavy fuels in railroad diesels is based on a series of papers and discussions of these papers presented at a recent SAE meeting. At this meeting representatives of the fuel suppliers, the engine builders, and the railroad users presented their findings and views, based on work with this type of fuel in railroad diesel engines in the past few years.

The papers

"Heavy Fuels for Railroad Diesels," **by W. F. Collins and K. D. Relyea,** New York Central System; **B. W. Geddes and N. H. Rickles,** Esso Research & Engineering Co.

"Are Light Residual Oils Economy Locomotive Diesel Fuels?" **by P V. Garin,** Southern Pacific Railroad; **J. L. Broughten,** Union Oil Co. of Calif.

"Trends in Residual Fuels," **by R. W. Van Sant, Jr., and A. S. Orr,** Gulf Oil Corp.

"Laboratory Full-Scale Engine Testing of Railway-Type Fuels," **by J. D. Carmichael, J. V. Kalb, and P. Kalil,** Texas Co.

"Microscopy in the Examination of Diesel Fuels," **by F. G. Rowe and H. F. Nicolaysen,** Continental Oil Co.

"Bifuel Approach to Burning Residual Fuels in Diesel Engines," **by W. C. Arnold and R. H. Beadle,** Fairbanks Morse & Co.; **and R. L. Logelin and H. D. Young,** Sinclair Research Laboratories, Inc.

The Discussers

C. G. A. Rosen, Caterpillar Tractor Co.

H. O. Lafferty and H. A. Williams, Electromotive Division, GMC

J. H. Heron, Great Northern Railway Co.

M. A. Pinney, Pennsylvania Railroad Co.

Ray McBrian, Denver & Rio Grande Western Railroad Co.

W. K. Simpson, Electromotive Division, GMC

C. E. Habermann, Socony Mobil Oil Co.

Secretaries' Reports of Oral Discussion by

P. L. Pinotti, Standard Oil Co. of Calif.

V. C. Barth, Chicago & North Western Railway System

Each of these papers (not the discussions) is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ each paper to members; 60¢ each paper to nonmembers.

and gutted valve seats. Valve failure can, in turn, lead to other problems, such as premature lube oil failure, filter and injector troubles. This means more frequent valve and valve-seat replacements are necessary. A more satisfactory solution appears to be the use of improved materials, such as stellite as a valve facing.

Another reason for reduced overhaul time is the increased wear that is experienced on many parts. Although, in certain test operations, some parts did not have higher wear rates, it seems clear that, in general, higher wear rates are likely for nearly all wearing components of an engine, when it is burning residual fuel. For example, Southern Pacific found cylinder liner, floating bushing, and top compression ring face wear with the light residual fuel to be twice what it was with the distillate. In no case, however, was the wear high enough to require premature replacement, that is, before the 2-year overhaul period. It was pointed out in discussion, though, that if any of these parts would be expected to last longer than from one overhaul period to the next, the increased wear rate would eventually result in increase parts cost.

Lubricating Oil—With the economy fuels lubricating oil tends to deteriorate more rapidly, since slightly higher combustion loads are accumulated in it. For Southern Pacific, this necessitates oil changes every two to three months, as compared with six months for distillate fuel operation.

The New York Central test unit also showed badly deteriorated lube oil when it was shopped after two months of service. Viscosity was 2200 SSU at 100 F, compared with a normal of 1000 SSU. In this case, though, the valve blow condition that developed might have been a factor, since poor combustion induced by the extremely poor valve condition could cause an abnormal amount of soot and partly burned fuel to contaminate the lubricant. Samples of oil taken prior to the valve blowing had not shown any unusual degradation.

In addition to requiring more frequent oil changes or using oils of greater additive reserve, or both, the increased oil contamination will also require more frequent oil filter changes.

Fuel Filter—Some investigators pointed out that filtration of residual-distillate fuels (or any noncompatible fuels) is more expensive and troublesome. Fuel centrifuging or more frequent fuel filter changes, it was said, will add another headache to the many shared by the maintenance crew. It will also add substantially to operating costs. A better solution was envisioned in the form of an improved fuel filtering system capable of removing the increased quantities of insolubles without an excessive rate of filter changes.

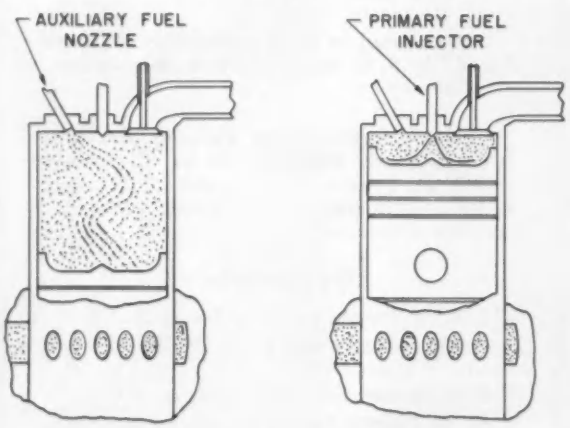


Fig. 2—Schematic representation of Bifuel combustion process showing (left) auxiliary fuel introduction early in compression stroke and (right) primary fuel injection at normal timing.

In case of 2-stroke engine, auxiliary fuel is preferably introduced directly into cylinder by means of properly timed second nozzle. In 4-stroke engine, auxiliary fuel can be introduced immediately ahead of air intake valves by means of individual low-pressure nozzles. Depending on volatility characteristics of auxiliary fuel, another method has been successfully employed in application of process to high-speed automotive-type, multicylinder engines. This method introduces fuel into intake air manifold by means of single nozzle.

During compression stroke, auxiliary fuel has ample time to become dispersed throughout cylinder. It is speculated that this fuel undergoes preflame oxidation (but not ignition) when properly proportioned with air charge. A favorable cylinder environment is thus created, which serves to trigger ignition of primary fuel when introduced in conventional manner. Consequently, ignition delay of primary fuel is materially reduced and in some cases virtually eliminated.

Microscopy

Microscopy, especially electron microscopy, is now being applied to the study of diesel fuels by many of the major oil producers and also by the larger consumers—the railroads. It provides an inexpensive and rapid substitute for long-term or accelerated storage tests to determine storage stability and filterability.

Two of the problems to be met in using microscopes to study diesel fuel quality are:

1. The broad range of sizes of the solid particles usually found—30 to 0.03 microns may occur within the same fuel.
2. Obtaining enough contrast between the particles and the oil to make the particles readily visible.

The first problem can be met by having both an electron and one or more types of optical microscopes, such as the phase and polarizing types. The electron microscope allows the study of the submicron particles. The light microscope provides a rapid method for making a count of the plus-micron particles, which to the consumer are more significant than the submicron particles.

Observations made with the light microscope are also helpful in providing some confirmation of those made with the electron microscope, where, because of the exposure of the sample to high vacuum and rise in temperature, questions have been raised as to whether or not changes in the sample may have occurred before the image could be observed.

In electron microscopy, contrast of the finest particles (up to 0.10 microns) may be low if the oil phase was not completely vaporized by the high vacuum.

With a light microscope, if the oil has a refractive index close to that of some of the particles, they may

scarcely be visible by transmitted bright-field illumination. Poor visibility will also result if the particles are transparent and the oil is highly colored.

The phase and polarized light microscopes both provide improved contrast.

In the phase type, a diffraction plate is added within the objective. An annular diaphragm is added below the condenser. This retards the central wave by ¼ wave length. The wave diffracted by the specimen is then reinforced by the wave transmitted through the surrounding space to form an image of the particle that is brighter than the background. Phase microscopy is especially helpful in improving contrast of highly transparent particles.

In addition to improving contrast, polarized light microscopy makes possible numerous determinative optical properties, namely, isotropy versus anisotrophy, one to three principal refractive indices, and several others. This type of microscopy is primarily applicable to the study of crystalline particles. It has been observed that many fuels have a considerable proportion of anisotropic crystalline particles. The polarizing microscope therefore provides a means of differentiating and possibly identifying crystalline phases occurring in a diesel fuel.

Bifuel Combustion Process

The Bifuel process embodies a 2-fuel combustion system whereby a small percentage of a suitable auxiliary fuel is introduced into the engine cylinder either during the intake stroke or early in the compression stroke but substantially prior to normal injection of the primary fuel, as shown in Fig. 2.

Among the benefits claimed for this new process are:

1. Reduced exhaust smoke density.
2. Increased exhaust smoke limited power output.
3. Reduced power parts wear.

Although intended primarily for large stationary engines, limited tests on small engines have been run to determine its feasibility for these engines as well.

Reduction in Exhaust Smoke—Studies carried out on the single-cylinder, variable compression ratio, turbulence-chamber ASTM cetane engine coupled to an electric dynamometer indicate the Bifuel process to have merit in reducing exhaust smoke. For example, in one of a series of experiments, a fairly heavy thermally cracked tar was employed as the primary fuel. This material possessed the properties shown in Table 1.

With the test engine operating at a speed of 1000 rpm, a compression ratio of 21/1, and 13 deg btdc injection advance, the smoke strip shown in the upper left of Fig. 3 was obtained.

Table 1—Analysis of Heavy Thermally Cracked Tar

Gravity, API	4.3
Viscosity at 100 F, SSU	110
Sulphur, %	3.62
Carbon Residue, %	3.3
Cetane No.	15

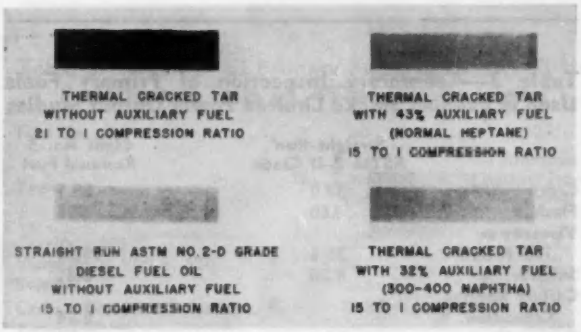


Fig. 3—Reduction in exhaust smoke (primary fuel injection rate was 13 cc per min).

Smoke strips shown here were obtained with Von Brand filtering-type, recording smokemeter. Tape speed: 2 in. per min; exhaust line back pressure: 1 in. of mercury; vacuum across tape: 2 in. of mercury. Smokemeter probe was installed about 24 in. down the exhaust line from engine.

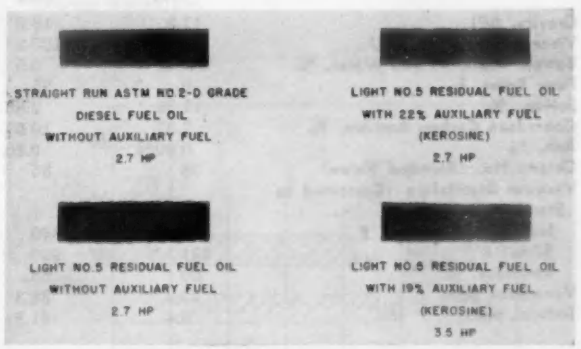


Fig. 4—Effect on exhaust smoke limited power output.

Smoke strips obtained with Von Brand smokemeter operated under same procedure as described in Fig. 3.

The smoke strip shown in the upper right of this figure is for the same primary fuel plus normal heptane as auxiliary fuel. The normal heptane amounted to 43% (by volume) of total fuel input to the engine. The operating compression ratio of the engine when using auxiliary fuel was 15/1 rather than 21/1 as previously required for the primary fuel alone.

The smoke strip in the lower right of this figure was obtained when using 32% (by volume) of petroleum naphtha of 42.0 cetane number as the auxiliary fuel.

For comparative purposes, the smoke strip for a straight-run ASTM 2-D grade fuel without auxiliary fuel is shown in the lower left of this figure. The similarity in exhaust smoke density shown on this strip with that obtained on the thermally cracked tar plus auxiliary fuel is apparent.

Effect on Exhaust Smoke Limited Power Output—A series of experiments carried out on the single-cylinder ASTM cetane laboratory engines indicates that the exhaust smoke limited power output of engines of this type can be increased by means of the Bifuel process. An example of this is shown in Fig. 4.

The engine was operated at 1000 rpm at a compres-

Table 2—Laboratory Inspection of Primary Fuels Used in Exhaust Smoke Limited Power Output Studies

	Straight-Run ASTM 2-D Grade	Light No. 5 Residual Fuel
Gravity, API	39.0	22.7
Flash, F	160	208
Viscosity at 100 F, SSU	38.4	102.3
Sulphur, %	0.20	0.61
Carbon Residue, Conradson, %	–	5.44
Cetane No.	54.0	26

Table 3—No. 6 Residual Fuel Analysis

	Min	Max
Gravity, API	11.8	18.0
Viscosity at 210 F, SSU	93.4	123.2
Bottom Sediment and Water, %	Trace	0.5
Pour Point, F	0	75
Sulfur, %	1.55	2.66
Conradson Carbon Residue, %	7.37	10.97
Ash, %	0.0024	0.66
Cetane No. (Blended Value)	35	35
Vacuum Distillation (Corrected to Standard Conditions)		
Initial Boiling Point, F	405	460
50%, F	891	930
Recovery, %	50	65
Vanadium, ppm	23.5	54.3
Sodium, ppm	3.4	41.9

Table 4—Analysis of Primary Fuels Used in 80-Hr Performance Tests on GM 2-71 Engine

Fuel No.	15	16	17	18	19
Type	50% alkylate bottoms, 50% alpha methyl-naphtha-lene	Alky-late bot-toms	Cata-lytically cracked distillate	Gaso-line	Straight-run ASTM 2-D grade fuel
Gravity, API	26.9	51.6	21.9	52.4	39.0
Viscosity at 100 F, SSU	30.9	30.8	39.9	–	38.4
Sulphur, %	0.64	0.05	0.73	–	0.20
Aniline Point, F	98.6	–	101.1	–	158.0
Olefins, %	2.5	3.6	12.8	–	5.0
Aro-matics, %	58.5	2.4	44.2	–	14.0
Distilla-tion, F					
Ibp	362	357	464	105	365
10%	394	369	481	172	421
50%	428	383	516	244	499
90%	465	468	617	301	593
Ep	526	611	645	350	645
Cetane No.	12	24	31.8	–	54.3
Octane No.	–	–	–	86.4	–
Reid Vapor Pressure, psi	–	–	–	6.9	–

sion ratio of 15/1. Injection advance was 13 deg btc.

The smoke strip in the upper left of this chart was obtained on a straight run ASTM 2-D grade fuel of 54 cetane number (see Table 2). No auxiliary fuel was employed. It will be noted that the output of the engine was 2.7 hp. This was obtained with a fuel injection rate of 15.8 cc per min.

The strip in the lower left of this figure was obtained with the engine operating on a light No. 5 residual fuel (see Table 2), also without auxiliary fuel. In this instance fuel input was adjusted to give the same hp as obtained on the previous fuel. This input amounted to 16.0 cc per min.

The increased blackness or opacity of this strip compared to the one obtained of the 54-cetane distillate is evident.

The smoke strip shown in the upper right of this chart was obtained on the residual fuel and 22% (by volume) of kerosene as auxiliary fuel. In this instance, also, the power output was held at the same level as before. Total fuel input amounted to 15.8 cc per min. However, input of primary fuel amounted to 12.3 cc per min and that of the auxiliary fuel, 3.5 cc per min.

The improvement in exhaust smoke density over that obtained when operating on light No. 5 residual without auxiliary fuel will be noted.

The lower right-hand strip shows the resulting exhaust smoke density when the engine was operated at a 30% higher horsepower output on residual fuel plus 19% (by volume) kerosene as auxiliary fuel. In this test the input of residual fuel to the engine amounted to 15.0 cc per min while the input of auxiliary fuel amounted to 3.5 cc per min.

Under these higher power output conditions the exhaust smoke density level was reasonably comparable with that obtained on the straight-run ASTM 2-D grade fuel at a lower power output (smoke strip in the upper left).

Wear Studies—A series of wear tests was conducted in a Fairbanks Morse 4-cyl model 38D 8⅛ × 10 engine (2-stroke, opposed-piston 720 rpm, 160 bph per cyl). The Bifuel combustion process was set up for kerosene auxiliary fuel injected at 120 deg btdc. The Primary fuel was a No. 6 residual fuel oil. The analysis given in Table 3 shows the range of fuel characteristics encountered. This fuel was prepared for burning in the engine by heating to a temperature to give a Saybolt viscosity of about 100 at the nozzles, centrifuging, and by 2-stage filtration. After a breakin period of 235 hr a complete engine inspection was made for base line wear data. The engine was then operated 500 hr at rated speed and load. All wear data were based on the latter 500 hr of test. This test procedure was repeated four times. The fourth test was extended to 1030 hr of operation. Fig. 5 shows the cylinder-liner wear results obtained. The engine was operated on the No. 6 residual fuel without the aid of the Bifuel combustion process in test 1. In test 2 the Bifuel process was used and employed 11% auxiliary fuel. A split Bifuel process engine was used in test 3 where two of the cylinders (a) operated with 11% auxiliary fuel while the other two cylinders (b) operated with 8% auxiliary fuel. Again in test 4 a split engine was used, but this time two of the cylinders (a) operated on No. 6 residual fuel while the other two cylinders (b) were aided by the Bifuel process em-

ploying 8% auxiliary fuel. The large reduction in wear rate from the first test to the fourth test is mainly due to changes in other engine and test variables. The percentage of auxiliary fuel used in each test is indicated above the bars. Note that the two tests are split engine tests where one-half the cylinders had either a different quantity of auxiliary fuel than the other half or none at all. This was done in an effort to minimize any effects due to changing residual fuel properties during the course of the tests. The graph shows no appreciable difference in wear rate results between 11% and 8% (by volume) auxiliary fuel, but the wear rate ratio of 1 to 3 when using either quantity as compared to standard combustion is readily evident.

Fig. 6 is a view of cutup cylinder liners used in tests 1 and 2. The major reduction in chrome surface corrosion that was obtained when operating with the Bifuel combustion process can be easily noted.

Performance Tests in Small Engines—A number of 80- and 100-hr tests have been run in small engines in order to establish the feasibility of running such engines for extended periods on low-grade fuels using the Bifuel process.

In one series of tests, five fuels were run for 80 hr each in a GM model 2-71 diesel engine. The Bifuel process was used in burning fuels 15, 16, 17, and 18 (see Table 4). These were low-cetane-number distillates. Fuel 19 was straight-run ASTM 2-D grade fuel, which was run for comparative purposes.

The 80-hr test period was established on the basis of the time required for the engine to consume approximately one drum of fuel (55 gal) under the test conditions employed. The engine was loaded by an a-c generator. The governed operating speed of the engine was 1200 rpm. The load maintained throughout the test was 25% of full load. The engine was run at a jacket outlet temperature of 135 F and a lubricating oil temperature of 165 F. An SAE 30 grade straight mineral lubricating oil was used throughout. Normal heptane was used as the auxiliary fuel during the tests on the four low-cetane-number primary fuels. This was introduced into the intake air stream in a quantity amounting to 12% (by volume) of total fuel used.

All four low-cetane-number fuels with the aid of auxiliary fuel ran quite successfully in the engine under test conditions employed. Little difference could be noted between the performance of these fuels and that obtained on the straight-run, ASTM 2-D grade fuel in respect to deposits and wear. The engine could not be started at room temperature on any of the low-cetane-number fuels without assistance of auxiliary fuel.

Tests similar to the above, except that kerosene was used as the auxiliary fuel, were run in a single-cylinder ASTM cetane engine for 100-hr periods. Laboratory inspection data on the primary fuels used in the two longtime tests on this engine are given in Table 5. The engine was operated at 13/1 compression ratio at a speed of 1000 rpm. Load was adjusted to 75% of maximum power at this speed. Input of auxiliary fuel amounted to 12% of total fuel. The auxiliary fuel was injected into the air intake at 15 deg before closure of the intake valve.

No operating difficulties whatsoever were encountered with either of these fuels.

Table 5—Analysis of Primary Fuels Used in 100-Hr Performance Tests on ASTM Cetane Engine

Fuel No.	20	21
Type	No. 6 residual fuel	Aromatic extract from SO_2 treat
Gravity, API	12.2	26.8
Viscosity at 100 F, SSU	2700.0	30.0
Sulphur, %	2.5	4.0
Carbon Residue, Conradson, %	10.87	–
Aromatics, %	–	81.0
Distillation, F		
Ibp	425[a]	350
10%	652	375
50%	915	442
90%	–	526
Ep	–	543
Cetane No.	35	10

[a] Vacuum distillation.

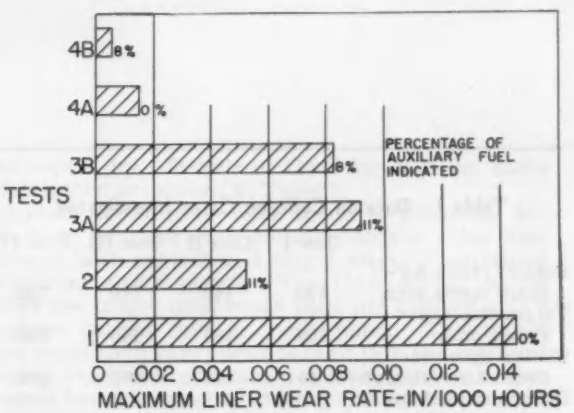


Fig. 5—Maximum cylinder-liner wear rates obtained with heavy fuel and Bifuel operation.

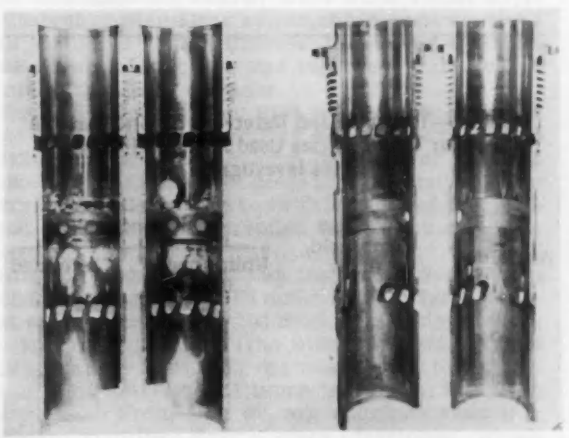


Fig. 6—Views of cutup cylinder liners used (left) in test No. 1 without auxiliary fuel and (right) in test No. 2 with 11% auxiliary fuel.

Overtaking, not head-on approach,

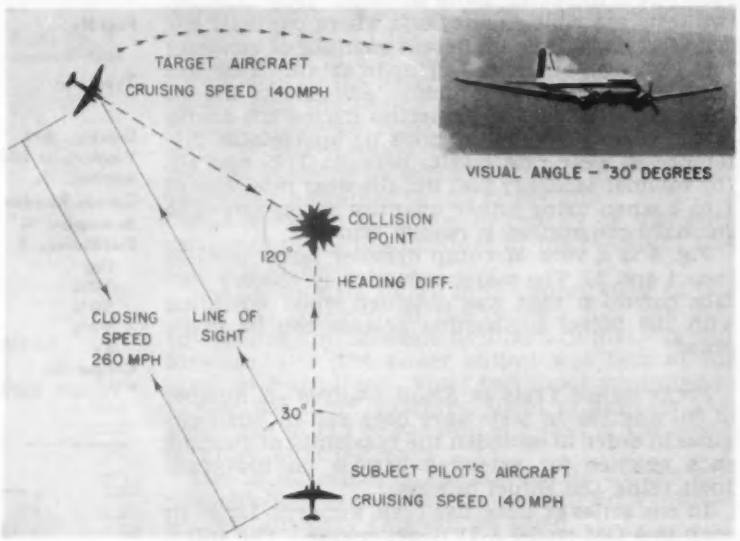


Table 1—Data on Collision Cases Investigated

	Case I	Case II	Case III	Case IV
Subject Pilot's Airplane Speed, mph	120	140	140	140
Target Airplane Speed, mph	150	140	140	140
Closing Speed between Aircraft, mph	60	140	260	280
Difference in Magnetic Heading between Aircraft, deg	30	60	120	180
Subject Pilot's Visual Angle from Straight Ahead to See Target Plane, deg	100	60	30	0

Table 2—Threshold and Detection Distances at the Four Visual Angles Used in the Collision Cases Investigated

Visual Angle, deg	Average Threshold, miles	Average Detection Difference, miles	
		Uninformed Pilot	Informed Pilot
0	11	3.5	5
30	13	5.0	4.5
60	11	4.5	4.5
100	10	3.5	4.75

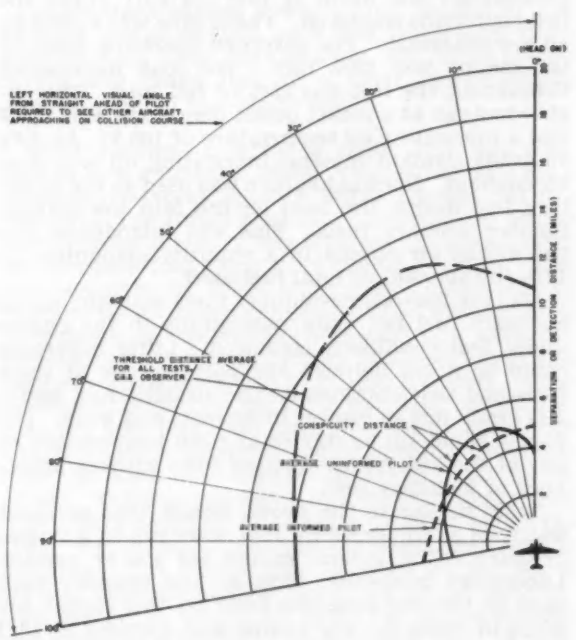

(HEAD ON)
LEFT HORIZONTAL VISUAL ANGLE FROM STRAIGHT AHEAD OF PILOT REQUIRED TO SEE OTHER AIRCRAFT APPROACHING ON COLLISION COURSE
THRESHOLD DISTANCE AVERAGE FOR ALL TESTS, G&A OBSERVER
CONSPICUITY DISTANCE
AVERAGE UNINFORMED PILOT
AVERAGE INFORMED PILOT
SEPARATION OR DETECTION DISTANCE (MILES)

Fig. 1—Telling a pilot he was on a collision route seemed to make little difference in distance detection except at head-on and at 100-deg visual angle approach. Average threshold distance was approximately three times the average pilot's detection distance.

found to be greatest cause of our

Mid-Air Collisions

Based on paper by **Wayne D. Howell and R. B. Fisher,**
Civil Aeronautics Administration

ON the average, a pilot notices another aircraft on a collision course with his own, only after two-thirds of the separation distance at the visual threshold has been closed. This startling fact has been brought to light by a study initiated at the CAA Technical Development Center and it marks a step toward finding a way to reduce the ever-growing menace of mid-air collision.

The study had two phases, designated uninformed and informed. In the first phase an effort was made to simulate the actual cockpit environmental conditions present during cruising flights between cities. The pilot was told to fly the same course twice, first using the VOR course deviation indicator, and secondly, using VOR and DME with a CAA Type IV pictorial computer. Since his eye movements were to be photographed during each run, he was told the analysis was being made to compare the amount of eye fixation time spent on the course deviation indicator while performing in-flight duties, as compared to fixation time spent on the pictorial computer. To prevent overconcentration on flight instruments, he was told the flight was strictly a VFR one and that in the interests of safety he should report any airplanes in the vicinity to the CAA copilot. Thus oriented, the pilot was left unaware of flying a collision course.

In the second, or informed phase, the intention was to simulate actual cockpit environmental conditions present when aircraft are flying in a terminal area. The subject pilot was told the purpose of the flight, and although apprised that he was flying a collision course, he did not know from what direction the other aircraft would approach.

Four Collision Cases Studied

With 64 airline pilots participating in the study, each flying two collision runs, a total of 128 test runs was racked up. Details of the four collision cases investigated are shown in Table 1.

Certain precautions were taken to maintain accuracy in running each collision course. The first paths of both subject and target aircraft contained 10 ground check points. The CAA copilot would notify the target pilot every time the subject pilot's airplane passed over a check point. The target pilot could then vary speed to maintain the constant closing rate and constant relative bearing angles present between aircraft during a level cruise collision condition. Each flight was synchronized on a time basis. Time that the subject pilot spotted the target aircraft was recorded and distance of separation between the aircraft was computed. A CAA engineer flying in the same airplane as the subject pilot and knowing exactly from what visual angle the target airplane was approaching, kept constant vigil until his eyes perceived the target aircraft. This time of detection was recorded and used to compute threshold distance.

Tests were held during VFR weather, since 84 out of 86 mid-air collisions during a period of five years (1948–1953) occurred during daylight or twilight hours with visibility in excess of three miles. The overall results obtained from this study of four collision conditions are compiled in Table 2 and portrayed graphically in Fig. 1.

Informing the pilots that they were flying on a collision course seemed to make little difference except at head-on and at 100 deg. The ratio of average threshold distance (the ultimate distance that a DC-3 can be seen with the naked eye) to the average pilot detection distance is almost 3 to 1 in every case. From this we can conclude that if a collision warning device were developed which would detect an airplane at threshold distance and indicate its direction of approach, it could extend

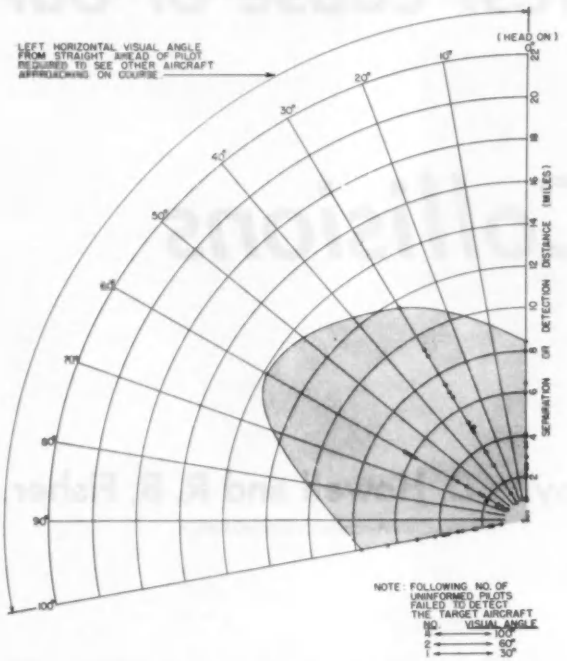

LEFT HORIZONTAL VISUAL ANGLE FROM STRAIGHT AHEAD OF PILOT REQUIRED TO SEE OTHER AIRCRAFT APPROACHING ON COURSE
(HEAD ON)
SEPARATION OR DETECTION DISTANCE (MILES)
NOTE: FOLLOWING NO. OF UNINFORMED PILOTS FAILED TO DETECT THE TARGET AIRCRAFT
NO. VISUAL ANGLE
4 ⟷ 100°
2 ⟷ 60°
1 ⟷ 30°

Fig. 2—Detection distances obtained from pilots unaware of flying a collision course varied from a maximum of 13½ miles at 60-deg visual angle to no detection at all.

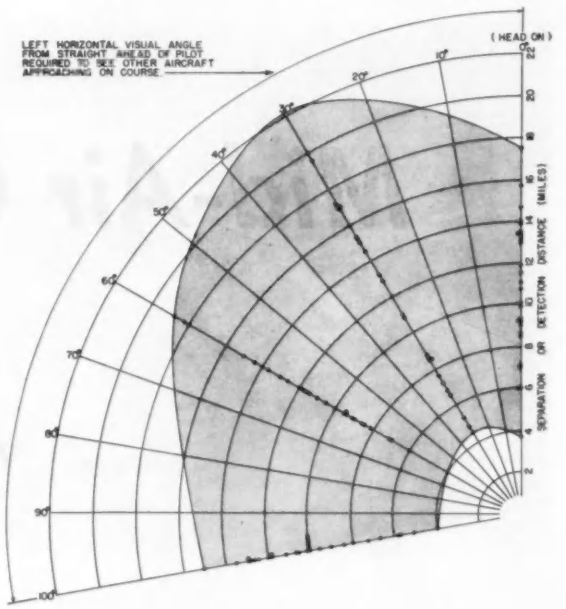

LEFT HORIZONTAL VISUAL ANGLE FROM STRAIGHT AHEAD OF PILOT REQUIRED TO SEE OTHER AIRCRAFT APPROACHING ON COURSE
(HEAD ON)
SEPARATION OR DETECTION DISTANCE (MILES)

Fig. 3—Distribution of detection distances obtained from threshold recorder during all collision runs shows greater deviation from mean in threshold distance recordings than in subject pilot detection distance recordings.

the present average pilot detection curve threefold.

The detection distances obtained from the subject pilot and the threshold recorder varied considerably in both informed and uninformed phases. In the uninformed phase, shown in Fig. 2, the detection distances varied from a maximum of 13½ miles at 60 deg visual angle to no detection. Seven pilots failed to detect the approaching aircraft—four at 100 deg, two at 60 deg, and one at 30 deg. A similar plot for the informed phase revealed the detection distance varying from a maximum of 10½ miles at 30-deg visual angle to no detection. Two pilots failed to detect the aircraft approaching from 100-deg left visual angle.

Distribution of the detection distances obtained from the threshold recorder during all collision runs is presented in Fig. 3. Threshold distances varied from a maximum of 22 miles at 30 deg visual angle to a minimum of 4 miles. Actually, there was more deviation from the mean in threshold distance recordings than in subject pilot detection distance recordings. Threshold recordings were much more easily affected by any slight change in atmospheric conditions, since the aircraft at this distance appears so small compared with its size at subject pilot detection distance. The wide variance in detection distance obtained from the subject pilots was caused primarily by the differences in pilot search habits.

From these test runs, the following conclusions were drawn:

1. Aircraft can be seen farthest under negative contrast conditions (dark aircraft against a light background) when there is a very high overcast.

2. Pilots could improve their ability at detection by developing better search habits, but, due to cockpit work load and other factors, they cannot be expected to detect an aircraft at threshold.

3. There is need for a collision warning device. A device to detect an aircraft approaching on a collision course at threshold and to indicate the direction of approach, could materially extend the average pilot detection curve. It is not enough to tell a pilot that an airplane within a certain proximity is a potential hazard. He must be given the direction of the approach.

4. The study gives a definite indication of expected average pilot performance in detection on a collision course while doing his normal cockpit duties.

5. The aircraft used in this study flew at relatively slow speed. With higher speeds and smaller profile such as characteristic of jets, the detection distances would be much less. As speeds become increasingly greater, the rate of closure of converging aircraft will exceed the limits within which human

visual capacity can insure collision avoidance.

6. Aircraft need to be more conspicuous.

Where Collisions Happen and Why

To determine if possible what factors had been most prevalent in past collisions, a collection of 92 reports, covering a period from 1949 to 1954, was selected for analysis. The primary consideration was the relative separation between two colliding aircraft, or their difference in headings prior to or at the time of collision. The summary of convergence angles for 50 mid-air collisions selected for study tends to contradict popular belief, in which we shared guilt, that the forward hemisphere contains the greatest danger by head-on approach. Actually, the greatest cause of past collision accidents was overtaking, in which one aircraft approaches another from the rear. Then, in order of ranking came 60-deg separation, 90-deg separation, 30-deg, 180-deg, 150-deg, and 120-deg separation.

What factor was most at fault for this situation? To answer this question, visibility was summarized by averaging visibility cutoff angles of various cockpits in popular aircraft. The results of this analysis are shown in Fig. 4. It was also apparent that the majority of aircraft in use today have little, if any, rear hemisphere visibility and practically no visibility below the horizon in the forward hemisphere. This is shown graphically in Fig. 5.

The last phase of this study was devoted to finding out where these mid-air collisions had been occurring, what distance relation they had to airports, and at what altitude they took place. The findings were as follows: 90% of collisions occurred within 5 miles of an airport; 54%, or better than half, took place within one mile of an airport, and over 50% of collisions for which an altitude could be established happened at or below 500 ft above the terrain.

(Paper, "Visual Avoidance of Mid-Air Collisions," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

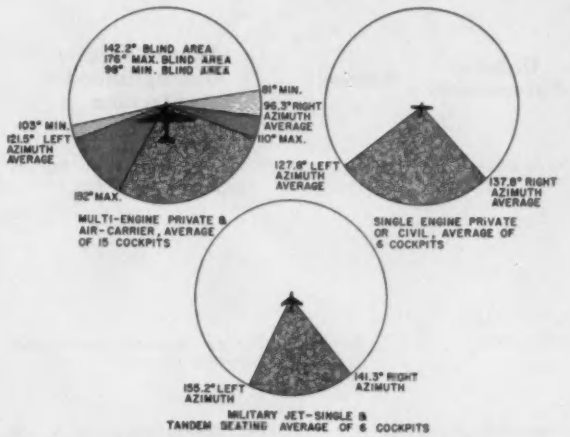

142.2° BLIND AREA
176° MAX. BLIND AREA
98° MIN. BLIND AREA
81° MIN.
96.3° RIGHT AZIMUTH AVERAGE
110° MAX.
103° MIN.
121.5° LEFT AZIMUTH AVERAGE
192° MAX.
MULTI-ENGINE PRIVATE & AIR-CARRIER, AVERAGE OF 15 COCKPITS
127.6° LEFT AZIMUTH AVERAGE
137.9° RIGHT AZIMUTH AVERAGE
SINGLE ENGINE PRIVATE OR CIVIL, AVERAGE OF 6 COCKPITS
155.2° LEFT AZIMUTH
141.3° RIGHT AZIMUTH
MILITARY JET-SINGLE & TANDEM SEATING AVERAGE OF 6 COCKPITS

Fig. 4—Pilot vision, right and left azimuth cutoff angles, in three general types of aircraft, makes evident the inadequate rear hemisphere visibility.

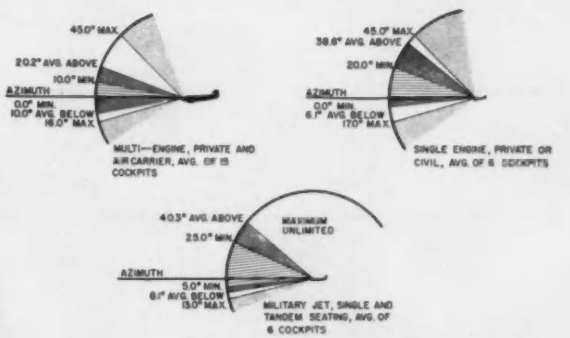


Fig. 5—Pilot vision, forward vertical cut-off angles, in multi-engine, single-engine, and military jets, shows lack of visibility below horizon in forward hemisphere.

■ *The main purpose of all the complexity we build into the modern automobile is to make it simpler.*

■ *The statement: "They are under study" is technical jargon meaning: "They're in the files somewhere."*

—P. H. Pretz

Order of Automaticity	Symbol	Human Faculty Accomplished by Machine	Characteristics of This Order of Automaticity	Examples of Devices and Machines Having This Order of Automaticity
Zero order	A_0	None. Replaces no human energy or control function	Includes all hand tools. They increase worker's efficiency, but replace no human function	shovel, knife, hammer, pliers
			Includes all hand energized machines. They give mechanical advantages but replace no human function	block and tackle, pencil sharpener, bow and arrow, pump, can opener
First order	A_1	Energy required to do basic machine function	Uses mechanical power source but machine feed and control completely dependent upon operator	cement troweling machine, bench saws, pneumatic drill, portable electric tools, floor polisher, wood lathe
Second order	A_2	All energy required to do basic machine function. Also automatic feed	Uses 100% mechanical power but operator must do complete set-up and provide on-and-off control	radial drill, bench lathe, power hack saw, pipe-threading machine
Third order	A_3	Controlling the machine	Completely self acting—the first true "automatics". "Open loop" performance	turret lathe, transfer machine, grinding machines, gear hobbers; screw machines; special manufacturing machines such as for cigarettes, lamp bulbs, and bottling
Fourth order	A_4	Monitoring machine performance	Measures machine performance, compares to a standard, and corrects machine as necessary. "Closed loop" feed-back control performance	ruling engine, honing machines, cold-reduction mill, chemical-process plants, oil refineries, generators, speed regulators, level controls

MEASURING

THE "automation yardstick is an attempt to measure automation. Its scale is based on two factors —energy and information. Energy does the job, and how the job is done is controlled by information. Classifying automation consists mainly of classifying the information that a machine uses. And each of man's faculties that can be performed by a machine raises the automaticity of that machine. The character A is used to represent the automaticity scale.

The class of hand-powered mechanisms, including hand tools, that provide none of the energy to a job, and only a negligible amount of the information required to do a job are shown symbolically as A_0. A_0 represents the zero order of automaticity.

The simplest devices that replace any of man's efforts are the power tools. These provide most of the energy required to do a job. A man's duties when using a power tool are mainly controlling it and feeding work to it. Because one of man's faculties, providing energy to do the basic job, has been allotted to a machine, the machine achieves a quality of automaticity. The powersaw, jack hammer, cutting torch, and punch press are in the class of tools having this first order (A_1) of automaticity.

The class of power tools that also possess power feed, such as radial drills, cutoff saws, and bench lathes, possess the second order of automaticity, A_2. These machines provide all of the necessary energy for a given operation. Control is still the job of the operator. But once the work is in place, and tooling is set up, all he needs to do is to start or stop the machine, or change controls.

Once we have power drive and power feed, the next logical step is to have the machine control itself. Machines that control their operations have the third order of automaticity, A_3. The information, or how to do the job, including the concept of skill, is built or set into the machine function, the tooling, and the control system. Examples of A_3 machines are automatic nail machines, automatic die-casting machines, and automatic-cycle machine tools.

Let's see what is meant by control of a machine.

Order of Automaticity	Symbol	Human Faculty Accomplished by Machine	Characteristics of This Order of Automaticity	Examples of Devices and Machines Having This Order of Automaticity
Fifth order	A_5	Performing calculations	Machine control is based on automatic solution of control equations	machines that use small, special-purpose computers
Sixth order	A_6	Obeying complex logic performs "deductive reasoning"	Machine control is based on automatic solution of complex formal logic conditions (A_6 and A_8 overlap somewhat)	telephone circuits, bowling-pin spotter, elevator controls, cypac machine controls, "Robots"
Seventh order	A_7	Learning by experience	Machine learns from its mistakes and attempts different modes of operation as necessary, and improves its techniques	A paper-talk machine which is theoretically possible but has not yet been attempted
Eighth order	A_8	Performs inductive reasoning. Has intuition and executive-type judgment	Machine extrapolates from its experience and forms modes of operation beyond actual experience, resembling intuitive operation and judgment	This could be an automatic Operations Research machine that sets up much of its own local programming
Ninth Order	A_9	Creativeness—originality	Machine comes up with original, creative concepts and can work beyond its programming	As there is no agreement what constitutes creativeness for men, there will be no agreement on creative machines. Do we want a machine of this type?
Tenth order	A_{10}	Dominance	Machines give the orders to the operators and designers	Science fiction writers take over from here. A dictatorship by machines!

AUTOMATION

Based on paper by **G. H. Amber and P. S. Amber,** Amber Brothers, Inc.

Control in its simple form consists of turning on or actuating a station; or as in the case of the turret lathe, transferring from one operation to the following one on the same machine. Obviously, a control function built into an A_3 machine, such as a modern automatic-cycle machine tool, can also be used to actuate the control system on a succeeding machine. Whenever we have a series of A_3 machines with integrated sequential control systems, we have automation.

"Detroit" automation is largely of this type. Most of the individual machine tools are A_3. The machines are coupled together by conveyors, indexers, manipulators, and positioners. These "transportation machines," between the machine tools proper, are also A_3. The proof of this is that they are completely automatic, providing all necessary energy, and too, by means of built-in routing and guides, the necessary preprogrammed information.

The information built into a machine is really a form of programming. For instance, an automatic screw machine obeys the program determined by the sequencing and setup of the tools on the turrets. A_3 programming is always accomplished by "hardware," straight mechanical, electromechanical, or electrohydraulic devices, such as followers and piece-part duplicators.

Today's automation is almost entirely A_3. Functionally, the various machines are usually arranged output of one machine to input of the succeeding one.

The complex A_3 automation systems obey the program designed into them faithfully. Too much so at times. The principal drawback of A_3 is this "blind obedience" characteristic. The machine goes right ahead, even if the tool is defective, or the parts fall outside of limits. This characteristic of not automatically checking up on a machine performance is called "open loop" by control designers. The A_3 machines are all open loop, excellent for most routine heavy manufacture—not quite precise enough, or sufficiently flexible for some high-accuracy requirements.

Machines that check on their work can be said to

have some judgment. These completely "closed-loop" machines possess the fourth order of automaticity, A_4. They monitor their own output, automatically making corrections to their settings as necessary. Or, as with some automatic honing machines, they continue with their function until the part is to proper size. A_4 machines of the self-correcting type are most frequently encountered in continuous processes. To be properly A_4, the feedback (self-correcting signal) must refer the basic work being performed to a standard. Any necessary linear corrections can be made by means of power-servo actuators. Incremental corrections are accomplished by "stepping." An incidental, nonbasic, self-regulating feature of a machine such as speed, temperature, or voltage does not necessarily make it A_4, as the work proper is not directly affected.

The dimensions of parts produced on a machine usually exhibit a natural tolerance caused by the organic nonassignable variation of the machine. Therefore, the dimensions of individual parts are usually of a random nature within the machine's dispersion zone, following the normal probability curve. The size of any individual part may fall anywhere from the high to the low-tolerance limit and still be acceptable. Having a sensitive, closed-loop, self-correcting A_4 machine respond to individual measurements will only cause it to chase from one dimension to another. The outcome is that the machine's dispersion pattern is amplified. Thus the A_4 machine could produce more rejects than a conventional A_3 machine if the A_4 control system is not adequate.

One practical solution towards having self-correcting features, without being distracted by the normal range of measurements, is accomplished when the machine remembers a part dimension and does not initiate corrective action until two or more parts indicate a definite trend or drift that must be corrected. This is known as post-process zone control.

Another solution is to compute the machine-mean, the centerline of machine performance, for use as a self-correction index, instead of using an individual piece-parts measurement. This can be accomplished by means of small built-in special-purpose analog computers. The computer calculates the machine-mean by averaging individual measurements. An advantage of a computed machine-mean is that the same computation is usable for an automatic quality control computer.

A computer in a machine's functional control system or program control system indicates that the machine possesses the fifth order of automaticity, A_5. Machines of the fifth order of automaticity do not depend on a direct control or feedback signal. Instead, these A_5 machines respond to a mathematical function of either the control or feedback signal.

A_5 machines can compute the machine-mean to be used as a reference for self-correcting machines or to be used for further automatic quality control computations.

The possibilities for A_5 machines, based on computer control, are endless. Other examples of A_5 machines with built-in computers are machines that would automatically "optimize" by solving maximum versus minimum relationships. In plain words, machines with small built-in special purpose computers can do some of the routine design of the product they produce. An example would be a punch press that automatically positions the stock so that the maximum number of piece-parts could be stamped out of the minimum amount of stock. Or, a machine that designs and fabricates a wide range of shock absorbers, in accordance to dial settings of damping rate, travel, and frequency.

A machine tool with a built-in automatic machinability-computer would be another example. Such a machine tool would remove metal at the fastest permissible rate, taking into account the tool, surface speed, material, and other machinability variables, even if they are continually changing.

The next big step in automatic machinery, and automation involves A_5 machines. True, they may be years away, but only because of the normal inertia of industry and the big investment in machine tools. But the trend is toward A_5. What is more, the techniques and hardware for making up the many small analog computers so necessary to A_5 machines, are already at hand.

Orders of automation of A_6 and greater, as shown in the table at the beginning of this article, are the result of some crystal gazing at the possibilities when higher orders of automation are commonplace.

(Paper, "A Yardstick for Automation," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Clean-Burning Gasoline

■ *To make a clean-burning gasoline, look to the bottoms. Keep the heavy material out of the gasoline. With the aid of these precepts it is possible to make an exceptionally deposit-free gasoline simply by keeping a careful check on its hydrocarbon constituents.*

—L. B. Shore and K. F. Ockert

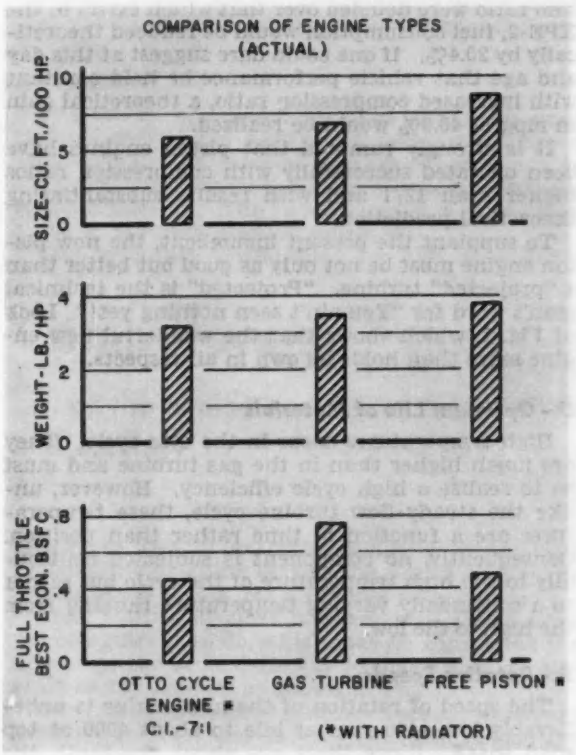


Fig. 1—This is what the proponents of three types of engines see as the ultimate. Note how well the new piston engine (otto cycle) stacks up with the gas turbine and free-piston engine.

Will the Piston Engine Make Good?

Based on paper by **D. F. Caris,** General Motors Corp.

LET'S assume the gas turbine has been used in the automobile since its inception around the turn of the century. Let's imagine great strides have been made in its development, tending to improve overall performance and specifically its fuel economy, with the paramount advances being:

- Gradual improvement in compressor and turbine design which have raised internal efficiencies to approximately 85 to 88%.
- Development of a satisfactory regenerator which, although adding to engine size, has eliminated the high-temperature exhaust problem and significantly improved cycle efficiency.
- Further improvement in cycle efficiency through increase in turbine inlet temperature made possible by advances in turbine blading.

As a result of this progress, average mpg at 40 mph has improved from about 8 in 1930 to 13 at the present time. Acceleration characteristics have not shown comparable improvement, however. Acceleration lag is believed likely to continue as an inherent characteristic because of the indirect method of increasing airflow.

Within the past few years a modification of the gas turbine, called the free-piston engine has appeared on the market. Its turbine compressor gasifier portion has been replaced by two opposed pistons. The cylinder in which the pistons reciprocate serves as the combustion chamber and the compression work is done by the pistons as the combustion products drive the pistons toward their bottom-dead-center positions. Expansion of the combustion gases in the cylinder lowers their temperature considerably before entry to the turbine. This is very advantageous in eliminating critical materials such as nickel and cobalt in the turbine blading. This cycle appears to give a fair gain in economy, although noise is a problem and there is still some acceleration lag.

Now let me tell you about a new type internal-combustion piston engine based on the otto cycle. The inventor reasons this way: If the free-piston gasifier serves effectively as a compressor by using part of the energy of the expanding gases, why couldn't a similar principle involving pistons be conceived which would use all the energy of the gases, part for the compression portion of the cycle and the remainder going into useful output? In this way the turbine member with its extremely

Fill 'Er Up!

Gas Turbine	20 gal
7/1 Compression Ratio Piston Engine	12 gal
Projected 12/1 Compression Ratio Piston Engine	7.2 gal

(For the same miles traveled in each case)

high rotative speeds, critical blading material, and 85% internal efficiency would be eliminated. This is the question raised by engineers a few years ago and today they have an answer in terms of the XPE-2, the second experimental piston-engine model which has just completed 30,000 miles of trouble-free operation.

This unit has six vertical cylinders, each with a single piston operating on a 4-stroke cycle. The compression ratio is 7/1 and fuel is mixed with air before admission to the cylinders in correct ratio for complete combustion by use of a single venturi device called a carburetor.

Power pulses to the crankshaft, which converts reciprocating motion to rotary motion, are equally spaced, thus operation is quite smooth. Balancing the engine was quite simple, thanks to prior developments. In size and weight per horsepower output the engine compares favorably with both gas turbine and free-piston engines. Test cell and road testing have revealed many characteristics desirable for passenger car application which, summed up, spell out what customers demand—PERFORMANCE. Each letter stands for a particularly outstanding quality as we shall show.

P - Proved Reliability

Reliability is borne out by 30,000 miles of road testing which covered acceleration tests, high-speed operation, and intermediate constant-speed economy runs. Disassembly of the engine uncovered no sign of excessive wear. Comparatively low speed and low temperature of operation should result in considerable advantage over the turbine engine in reliability. There is reason to believe that it will give 100,000 trouble-free miles of service in a passenger car.

E - Economy

Perhaps the brightest spot in the picture was the improved fuel economy at the comparatively low compression ratio of 7/1. An astounding 20 mpg was obtained at 40 mph constant speed on level road. This exceeds present turbines at the same speed. Even more remarkable, at 30 mph, 23 mpg was obtained. And at both lower and higher speeds economy was still relatively good, although the maximum was had around 20–40 mph. Considering the poor economy of the turbine at low car speeds and idle, the city driver has much more to gain than the 40-mph constant-speed figures indicate.

The new piston engine will idle at 400 rpm for one hour on ½ gal gasoline! The present turbine would consume from 2 to 3 gph and idle at several thousand rpm.

R - Response

One of the most exciting features of the new engine is its positive response when a greater weight of charge is admitted to the cylinder by increasing the throttle opening. A car equipped with this engine is agile and until you have driven it you have no idea what driving can be like. This is a feature that will sell.

F - Future

If the present is bright, the future looks brilliant for there is room for improvement. If the compression ratio were doubled over that which exists in the XPE-2, fuel consumption would be reduced theoretically by 20.4%. If one could dare suggest at this day and age that vehicle performance be held constant with increased compression ratio, a theoretical gain in mpg of 40.8% would be realized.

It is strongly rumored that piston engines have been operated successfully with compression ratios higher than 12/1 and with results substantiating theoretical prediction.

To supplant the present incumbent, the new piston engine must be not only as good but better than a "projected" turbine. "Projected" is the technical man's word for "You ain't seen nothing yet!" Look at Fig. 1, which shows that the wonderful new engine more than holds its own in all respects.

O - Optimum Life of Materials

High temperatures occur in the otto cycle. They are much higher than in the gas turbine and must be to realize a high cycle efficiency. However, unlike the steady-flow turbine cycle, these temperatures are a function of time rather than position. Consequently, no component is subjected continually to the high temperature of the cycle but rather to a continually varying temperature ranging from the high to the low.

R - Rotative Speeds

The speed of rotation of the new engine is unbelievably low—400 rpm at idle to about 4000 at top road speed. Since these are about one-tenth the rotative speeds in our present engines, exact balancing is considerably less critical. If the piston engine is balanced to 0.5 oz-in., the present gas turbine would have to be balanced to 0.005 oz-in. for comparable smoothness.

M - Materials

Absence of a severe temperature problem permits the use of low-cost, readily available materials in the new engine. Although cast iron and low alloy steel are the principal materials now in use, both aluminum and magnesium could play important roles.

A - Airflow

For best economy only enough air need be supplied for complete combustion of the fuel. Actually, airflow with the new piston engine is only about one-eighth that of our present engine of comparable power. This permits the use of smaller size manifolding and ducting. It means that a relatively small air filter can be used.

N - Noise

The sound level is relatively low when exhaust pulsations are damped with an exhaust line muffler. Transmission noise is comparatively easy to reduce to an acceptable level because of the low gear reduction.

C - Control

A butterfly-type valve below a carburetor controls engine speed by regulating the weight of charge entering the cylinders. The tendency of the air/fuel ratio to remain relatively constant throughout

the speed range and during acceleration and deceleration contributes to high combustion efficiency.

E - Exhaust

The volume of exhaust gas to be handled is small relative to the gas turbine of comparable power. This means that a lower exhaust pressure can be obtained with smaller and less space-consuming exhaust ducting. The new engine is also less sensitive to elevated exhaust pressure.

The inventors' enthusiasm for this new piston powerplant is understandable. At the same time, they realize novelty is not enough; that the new engine must offer something superior enough to warrant change if the highly specialized passenger-car field is to be penetrated. They feel that the new piston engine qualifies in every respect and predict that it will conquer the passenger-car field.

(Paper, "Are Pistons Here To Stay?", on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Computers . . .

. . . of the analog and digital type take over to solve industrial problems with speed and accuracy.

Based on paper by **Herman Epstein,** Burroughs Corp.

HERE, by way of example, is how a digital data handling machine tackles the simple problem of solving $A - B + C = X$ for a number of values.

After stating in clear mathematical terms what the computer is to do, which may be considered the first step, the second step is to make a block diagram of the system, as shown in Fig. 1.

Using the instructions given in Table 1, which are available for carrying out any problem, reduce the instructions to writing, as shown in Table 2.

With these instructions (Table 2) to follow, obtain and add *A* in the cleared accumulator, obtain and subtract *B* from the uncleared accumulator, obtain and add *C* into the uncleared accumulator, store the sum and print out the sum. This sequencing is done by means of the control. The instructions are fed in through the input or are stored in the memory. The arithmetic unit does the actual arithmetic and the output device prints or displays the results.

The last step is to review what was done in Fig. 1, Table 1 and Table 2.

(Paper, "Computational Devices in Industrial Use," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

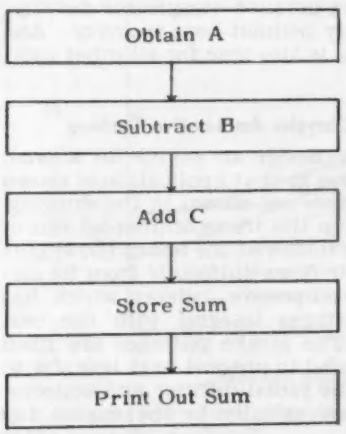


Fig. 1—Block diagram of system.

Table 1—Dictionary of Commands for Assumed Computer

Symbol Form	Explanation
00	Stop
01	Print from the given address
02	Store the contents of the accumulator in the given address
03	Clear the accumulator, and then add into the cleared accumulator the word obtained from the given address
04	Add into the uncleared accumulator the word obtained from the given address
05	Subtract from the uncleared accumulator the word obtained from the given address
06	Multiply the word in the accumulator by the word obtained from the given address, leaving the product in the accumulator
07	Unconditional transfer
08	Transfer if the word in the accumulator is minus.

Table 2—Program for Task

Memory Address	Contents of Address	Explanation
000	Vacant	
001	03007	Obtain the word in address 007 and add it into the cleared accumulator
002	05008	Obtain the word in address 008 and subtract it from the word in the accumulator, leaving the difference in the accumulator
003	04009	Obtain the word in address 009 and add it into the uncleared accumulator, leaving the sum in the accumulator
004	02010	Store the contents of the accumulator in address 010
005	01010	Write out the contents of address 010
006	00000	Stop the computer
007	.....	A
008	.....	B
009	.....	C
010	.....	The sum X

Automotive Gas Turbine Making

Based on paper by **G. J. Huebner, Jr.,** Chrysler Corp.

CHRYSLER has high hopes for the regenerative gas turbine as the ground vehicle powerplant of the future. This optimism is based on years of experimentation with regenerative turbines descended from the one shown in Fig. 1.

Today's gas turbine rivals conventional piston engines in its efficiency and many methods are known for improving the cycle efficiency even more. A thermal efficiency of 40% in the next decade seems possible and this compares with 28% as about the best that can be obtained with the piston engine. Furthermore, the gas turbine has a torque curve rivaling the steam engine and it is possible for it to match the power requirements of an automotive vehicle much more closely than a reciprocating engine.

The turbine is a durable engine. The Air Force has found it to last longer than the piston engine and nothing we have found contradicts that experience. A gas turbine could probably be designed to last indefinitely simply by increasing the mass of rotating parts and decreasing the temperature and speed of operation. While lasting nearly forever, it would take nearly forever to get away at a stoplight. Fortunately, advances in the field of high-temperature materials and refinements of design techniques are increasing the durability of the few troublesome parts remaining.

With proper tooling and production in the right quantities there is no reason why the gas turbine should suffer a cost penalty. The engine has only a few moving parts, but these parts are strange and will require new and as yet undeveloped production approaches. The turbine is a challenge to engineers and just as great a challenge to management. If turbines are ever to be produced in quantity, radical manufacturing changes will be necessary. They cannot be produced in small quantities or the cost will be too high. Therefore, one can predict that when fully accepted by the automotive companies, they will be produced in properly tooled plants in economically sound volume.

Merits of Regeneration

Chrysler's turbine development work has been concentrated on engines with exhaust heat recovery. Simple-cycle engines have been tested; many types of heat exchangers have been tried and many found not to work. Our aircraft gas turbine had a tube bundle through which the compressed gases made three passes while the tube was surrounded by exhaust gases. This was satisfactory for aircraft, but its effectiveness for reasonable size and weight was limited to about 70%. For automotive use a heat exchanger has to be about 85% effective to compete with the piston engine.

What regeneration does for the gas turbine can be seen by reference to Fig. 2. This shows the effect of regeneration and pressure ratio on thermal efficiency at 1600 F nozzle inlet temperature. Lines to the left of the ordinate represent a nonregenerative engine; solid curves represent performance of a regenerative engine. Increased pressure ratio within reasonable limits is no substitute for high regenerator effectiveness.

The opinion has often been expressed that the need for regeneration would no longer exist if nozzle inlet temperature was raised a few hundred degrees. We do not fully agree with this and Fig. 3, showing the effect of regeneration and cycle temperature on the thermal efficiency, is offered by way of explanation. These curves are all drawn at a pressure ratio of 4/1. Note the enhancing of the regenerative effect at the higher cycle temperatures. The two effects are not therefore incompatible. Higher cycle temperatures and higher regenerator effectiveness go hand in hand to increase thermal efficiency and point the way to future development.

It has been suggested that regeneration can cover up component troubles and that its effect can actually substitute for, say, poor compressor efficiency. Fig. 4, showing the effect of compressor efficiency and regeneration on thermal efficiency, makes plain how much more important increased compressor efficiency is with regeneration than without it. A bad compressor could get by for a while on a regenerative engine, but regenerator size and weight would soon catch up with it and force the same attention to careful and detailed compressor development that is necessary without heat recovery. And to a lesser degree this is also true for all other components.

Design of First Chrysler Automotive Turbine

Our initial effort to design an engine for a small car and make it behave in that application is shown in Fig. 1. With changes not shown in the drawing, it is the engine used in the transcontinental run of March, 1956. The air intake at the left of the engine is annular and the air flows uniformly from its circumference to the compressor inducer which has two rotating axial stages integral with the cast radial compressor. The intake passages are lined with insulating material to prevent heat transfer to the incoming air. The radial diffuser and collector deliver the air at low velocity to the engine top

Strides

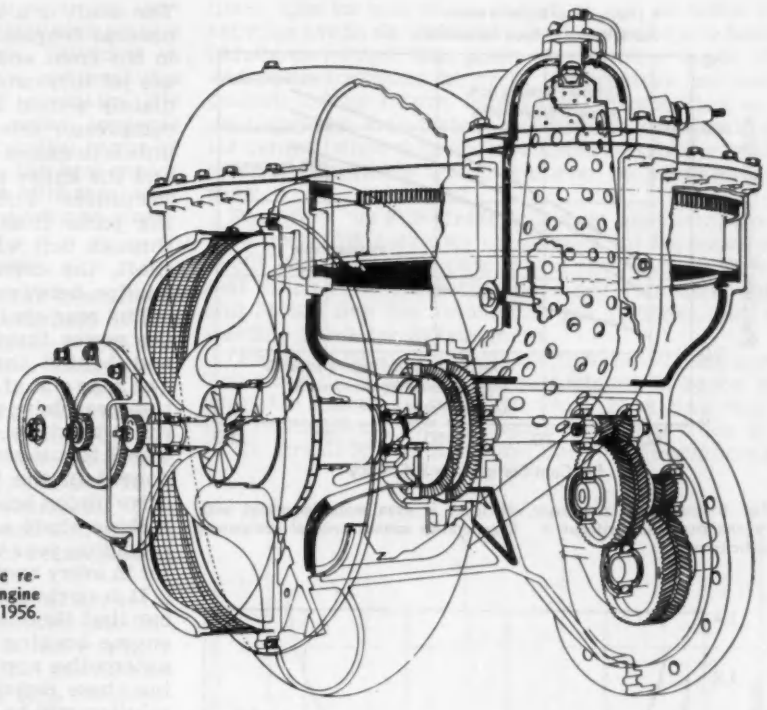


Fig. 1—Daddy of all Chrysler automotive regenerative gas turbines and basically the engine used in the transcontinental test run of 1956.

cover, which directs it downward through the regenerator to a plenum chamber communicating with the space surrounding the burner combustion sleeve. The flow, introduced into the burner, after heating is directed downward through the burner sleeve and a conductor pipe to a vortex chamber communicating to the first-stage nozzle. After flowing through the two turbine stages the exhaust gas passes upward through the regenerator and is again directed downward, by the top cover, to the exhaust pipe which is located diametrically opposite to the burner in this drawing, hence not shown. The housing is cast iron. Both engine top cover and burner cover are cast aluminum.

Accessories are driven from a reduction gear mounted at the front of the engine and meshed with a pinion on the gas generator shaft. The accessory reduction gear ratio is 8.3/1. The gear drives a shaft which runs parallel to the gas generator shaft, driving the fuel pump, regenerator, and electric starter-

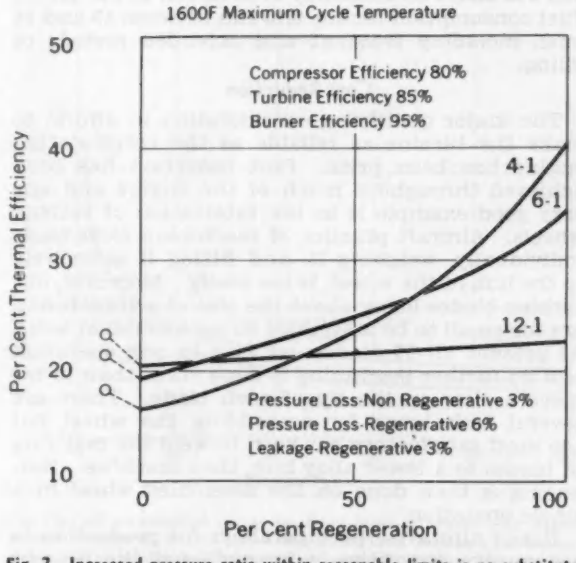


Fig. 2—Increased pressure ratio within reasonable limits is no substitute for high regenerator effectiveness.

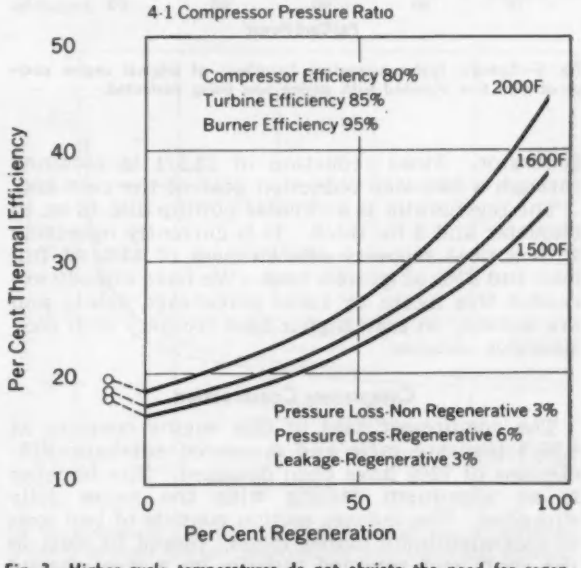


Fig. 3—Higher cycle temperatures do not obviate the need for regeneration, but employed together they do increase thermal efficiency.

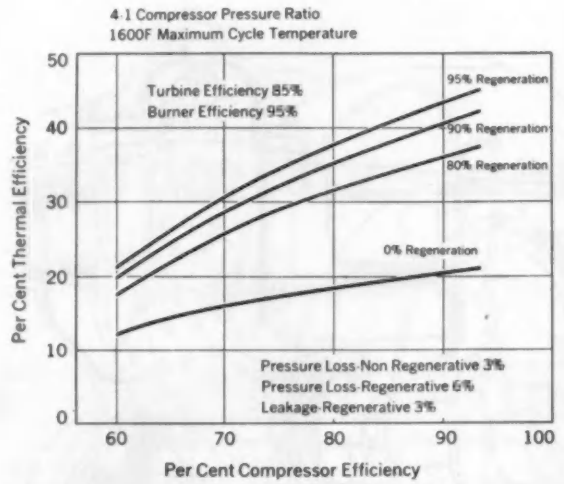


Fig. 4—Increased compressor efficiency is even more important with regeneration than without it. Regeneration cannot conceal component deficiencies.

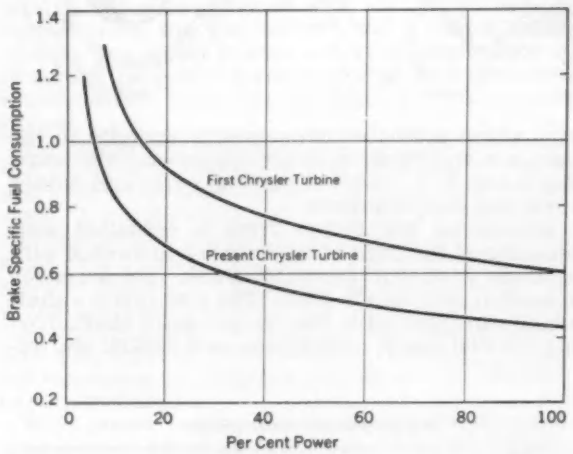


Fig. 5—Specific fuel consumption (gasoline) of original engine compared with that obtained with engine now being perfected.

generator. Final reduction of 12.5/1 is obtained through a two-step reduction gear at the rear end.

The regenerator is a circular builtup disc 18 in. in diameter and 3 in. thick. It is currently operating with a heat recovery effectiveness of 83% at full load and 87% at quarter load. We have already exceeded this figure by three percentage points and are working on even higher heat recovery with considerable success.

Compressor Construction

The compressor used in this engine operates at 4.25/1 pressure ratio and measured adiabatic efficiencies of 78% have been obtained. The impeller is an aluminum casting with the vanes fully shrouded. The inducer section consists of two rows of cast-aluminum blades loosely placed in slots in the shaft and retained radially by a steel shroud shrunk to the eye diameter of the impeller shroud. The shaft is a builtup steel type with a calculated natural frequency of 77,000 rpm. A roller bearing in the front end and a ball bearing at the rear end are jet lubricated. Shaft seals may be seen immediately behind the impeller and on the hub of the compressor drive turbine. Operating speed of this unit is in excess of 51,000 rpm, therefore components and the entire assembly are balanced to quite close tolerances. The entire assembly is made by stacking the parts from either end and is retained by a through bolt which passes down the center of the shaft, the drive of the assembly being taken by friction between the various parts.

The rear shaft is assembled in similar manner to the power turbine and is supported at its forward end, behind the power turbine, by a ball bearing. The rear end of the shaft is supported by the reduction gear drive pinion which is straddle-mounted in roller bearings. The ball bearing takes the turbine wheel thrust since there is no bearing thrust component in the herringbone reduction gear. Noise, drive pinion bearing troubles, and problems of power turbine shaft alignment caused us to replace this reduction gear with a single-step helical that is better in every respect.

It is obvious to anyone driving a turbine-powered car that there is a lag in acceleration and a lack of engine braking. These are deficiencies peculiar to automotive application. Progress made in overcoming these deficiencies indicates that a satisfactory solution will be reached.

On the transcontinental endurance run only two incidents marred the trip. One was a failure of a reduction gear bearing due to loss of oil when an oil line cracked in the reduction gear housing. Both design and gear have since been abandoned in favor of a new single-stage helical box. The other incident was the fatigue failure of a casting in the intake environment. Neither should have occurred, and both have been corrected. Repairs were effected on the spot without altering the engine.

Contrary to rumor, the regenerator was in full operation during the entire trip since it has a marked effect on efficiency even at full power levels. Fuel consumption for the trip ran between 13 and 14 mpg, including frequent and extended periods of idling.

Cost Reduction

The major qualifying consideration in efforts to make the turbine as reliable as the reciprocating engine has been price. Cost reduction has been achieved throughout much of the engine and one very good example is in the fabrication of turbine wheels. Aircraft practice of machining each blade individually, weighing it, and fitting it selectively to the hub of the wheel, is too costly. Moreover, our turbine blades being about the size of a thumb-nail are too small to be assembled on an individual basis. At present all 53 blades are cast in one operation and no further machining is done other than to remove a riser on the tip of each blade. There are several techniques for assembling the wheel but the most satisfactory has been to weld the cast ring of blades to a lower alloy hub, then machine. Balancing is then done on the assembled wheel in a single operation.

Use of aircraft-type superalloys for production in automotive quantities is impossible if the present world supply of alloy elements is used as a base.

Work has therefore been directed to obtaining materials which could be made from elements readily available and noncritical in nature. Progress to date indicates that current operating temperatures can be maintained for satisfactory operating life without the use of cobalt and with nickel contents low enough to be well within the practical range of availability. By way of illustration, the best material yet found for the burner liner is 1010 steel aluminized. In this application it is superior to stainless steel.

Prediction of Things to Come

Three charts will serve to tell what lies ahead. Fig. 5 shows the specific fuel consumption of the engine now being worked with, contrasted with the original engine. Fig. 6 shows this new turbine engine compared to a modern automotive piston engine. Fig. 7 presents three fuel consumption curves. The lowest is plotted from data released on the Napier Nomad compound engine. Just above is a curve for the estimated fuel consumption of a free-piston compressor and turbine combination. The top curve represents a generous prediction for an advanced and unconventional type of reciprocating engine.

Our concept of the fuel consumption of an automotive piston engine and of an automotive gas turbine in the not too distant future is shown in Fig. 8. In working with the components of this gas turbine our objectives call for approximately 85% compressor efficiency and 92% regenerator effectiveness. The former we have already achieved in past programs; the regenerator effectiveness we believe we know how to achieve. It remains to repeat it in the package size and at a cost reasonable for automotive use.

The thermal efficiency shown for this turbine is obtained at cycle temperatures readily obtainable with today's materials. The future of high-temperature materials is unknown but there are materials now available which will allow operation at 200 F higher than the nozzle inlet temperature shown here. The turbine curve, therefore, can be taken as showing available techniques and current cycle temperatures. From this point the turbine takes off and, with increases in cycle temperature believed possible in the future, leaves the reciprocating engine and the free-piston, gas-turbine combination far behind, since they are now using nearly the peak cycle temperatures which will ever be available to them.

For every 100 F increase in nozzle inlet temperature over this curve we can expect an increase of about 10% in specific output and about 5% in thermal efficiency. Even this does not represent the end of the line for automotive gas turbines, but a starting point for development.

(Paper, "The Automotive Gas Turbine—Today and Tomorrow," on which this abridgment is based is available in full, in multilith form, from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

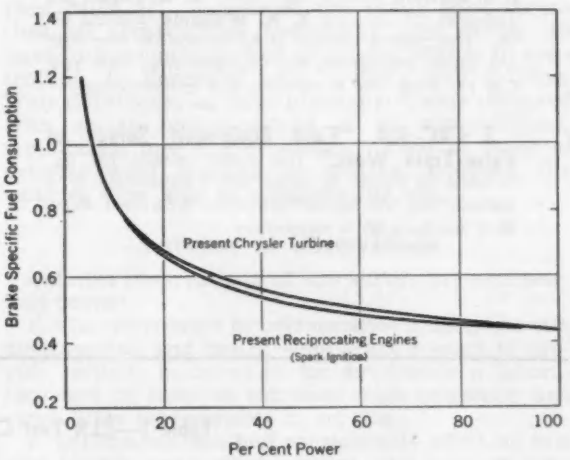


Fig. 6—Specific fuel consumption of present turbine compares favorably with that of a modern reciprocating engine, but room for improvement is evident.

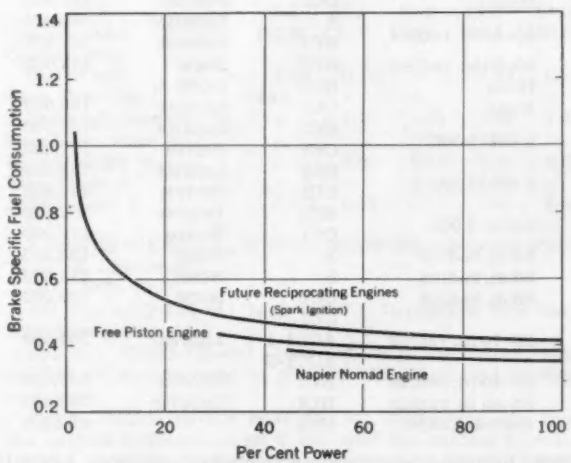


Fig. 7—Fuel consumption curves for three types of engine—the Napier Nomad compound, a free-piston compressor and turbine combination, and a yet-to-be-designed advanced reciprocating engine (the last two estimated).

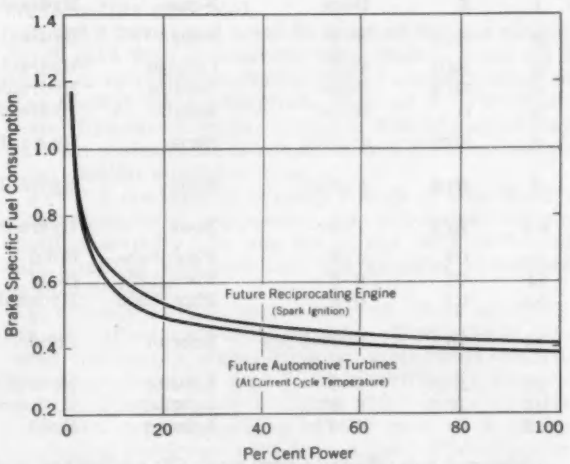


Fig. 8—Forecast of a coming event. Turbine will have a compressor efficiency of about 85% and approximately 92% regenerator effectiveness.

CRC Group Studies Why's and

Valve

This article is based on the following:

1. "Valve-Train Wear as Affected by Metallurgy, Driving Conditions, and Lubricants," a report of the Field Survey of the Camshaft and Valve-Tappet Wear and Corrosion Group of the Engine Lubricants Division of the Coordinating Lubricant & Equipment Research Committee of CRC, by **Vincent Ayres,** Eaton Mfg. Co.; **J. B. Bidwell,** Research Staff, GMC; **A. C. Pilger, Jr.,** Tidewater Oil Co.; and **R. K. Williams,** Lubrizol Oil Co. This paper is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York City 17. Price: 35¢ to members; 60¢ to nonmembers.

2. CRC-303, "Field Equipment Survey of Valve-Train Wear." This report contains 107 pp., including 16 figures, 32 tables, and 9 appendices. It is available from SAE Special Publications Department. Price: $3 to members, $6 to nonmembers.

DURING 1953 and 1954 a number of car manufacturers and oil companies reported field service problems arising from excessive wear of tappets and cams. Several papers appeared presenting both field data and laboratory test results. However, the conclusions reached were not in general agreement. A realization of the large number of variables involved and the need for duplication of tests to attain reasonable statistical significance in wear tests made it appear that a cooperative effort would discover the facts most effectively. The CLR Camshaft and Valve-Tappet Wear Group was, therefore, formed with the long range objective of developing techniques for evaluating the

Table 1—CLR Test Car Information

Car	Camshaft			Valve Tappet				Max Compression Stress
	Material[a]	Taper	Surface Treatment	Type	Crown	Material[a]	Surface Treatment	
1	S	None	None	Hydraulic	None	CCI	Ferrox	161,000
2	HCI	6′–7′	None	Hydraulic	50–80 in. radius	S	Lubrite[b]	160,000
						HCI	Lubrite	141,500
3	HCI	4′–7′	Lubrite	Hydraulic	50–80 in. radius	HCI	None	173,000
4	HCI	None	Lubrite	Hydraulic	None	HCI	None	.....
5	S	None	Lubrite	Hydraulic	None	CCI	Lubrite	100,000
6	HCI	8′–10¾′	None	Hydraulic	0.003–0.005	HCI	Lubrite	162,500
						CCI	Ferrox	177,000
7	HCI	5′–8½′	None	Hydraulic	0.003–0.005	HCI	Lubrite	162,500
						CCI	Ferrox	177,000
8–9	HCI	7′–10′	None	Hydraulic	0.003–0.005	HCI	Lubrite	162,500
						CCI	Ferrox	177,000
10	CI	6′–8′	Phosphate	Solid	50 in. radius	S	None	135,300
11	CI	6′–8′	Phosphate	Solid	50 in. radius	S	None	119,800
12	CI	6′–8′	Phosphate	Hydraulic	50 in. radius	CCI	None	129,000
13	HCI	0.001–0.002 per in.	Lubrite	Solid	50–70 in. radius	CCI ACCI-1 ACCI-2	Lubrite	105,500
14	HCI	6′–8′	Lubrite	Hydraulic	30–40 in. radius	HCI	Lubrite	145,000
15	HCI	6′–8′	Lubrite	Hydraulic	30–40 in. radius	HCI	Lubrite	163,500
16	S	6′–8′	Lubrite	Solid	0.0024–0.0036	CCI	[c]	102,000

[a] Material code: S: carburized steel; CI: as-cast cast iron; HCI: hardened cast iron; CCI: chilled cast iron; ACCI-1: alloy-chilled cast iron-1; ACCI-2: alloy-chilled cast iron-2.

[b] Also grit blasted.

[c] Steam tempered—Lubrite optional.

Wherefore's of

Train Wear

compatibility of oils with valve gear of different designs and metallurgical combinations.

After considering the data available in the fall of 1954, this Group concluded that more extensive field test information was essential before their goal could be attained. A field test program was planned immediately and put into operation in the Spring of 1955. Cam and tappet wear, spalling, and scuffing in field service have all been investigated as functions of valve-gear design, metallurgy, lubricant properties, and type of operation. This test program was completed during 1956. (Complete data and results are published in CRC-303.)

Thirty laboratories submitted data on 295 cars of 16 different makes having a variety of camshaft and tappet metallurgy-design combinations (see Table 1) and operated on four different test oils (see Table 2). Results of this study have shown that oil composition, metallurgy, and design all have independent as well as related effects in controlling the degree of wear, scuffing, and spalling. Wide differences in these phenomena were observed with certain combinations of oil compositions, metallurgy, and engine design. Even in cases of extreme wear, spalling, or scuffing, however, the vehicles were able to complete the test.

Table 2—Laboratory Inspection of Test Oils

	Base Oil[a]	Code No.[b]			
		1	2	3	4
Gravity, deg API	31.4	29.6	28.8	29.4	29.4
Viscosity, SUS					
100 F	310.0	341.0	319.0	332.0	331.0
210 F	60.1	62.2	60.0	61.0	61.0
Viscosity Index	132.8	130.7	130.0	129.6	129.8
Neutralization No. (D-664)	0.04	0.16	–	0.48	0.20
Flash, Open Cup, F	445	–	–	–	–
Sulfated Ash, weight %	–	1.10	1.50	1.20	1.02
Phosphorus, weight %	–	–	0.20	0.05	–
Barium, weight %	–	0.67	0.52	0.62	0.62
Zinc, weight %	–	–	0.22	0.05	–
Sulfur, weight %	0.11	0.32	0.64	0.39	0.46

[a] Base oil is a 95 V.I., solvent-treated Midcontinent stock plus V.I. improvers.

[b] Oil code No:

Oil 1—(REO-128-54) base oil, V.I. improvers, and barium phenate.

Oil 2— (REO-129-54) base oil, V.I. improvers, zinc dialkyl dithiophosphate to provide 0.2% zinc, and barium sulfonate.

Oil 3—(REO-130-54) base oil, V.I. improvers, one-half the barium sulfonate in oil 2, one-half the barium phenate in oil 1, and zinc dialkyl dithiophosphate to provide 0.05% zinc.

Oil 4—(REO-131-54) same as oil 3 except that 0.5% of sulfurized olefin replaced the zinc dialkyl dithiophosphate.

Summary of Observations

Detailed observations of the survey are summarized below:

1. The differences in performance among the oils, metallurgies, and design were great enough to provide suitable background for developing a laboratory test or tests to correlate with camshaft and valve lifter performance in service.

2. Oil composition had considerable effect on cam and tappet wear when chilled cast-iron or steel tappets were used. With these tappets the two oils containing zinc dialkyl dithiophosphate gave considerably less wear than the two oils which did not contain this chemical.

3. Oil 3 gave least wear in most of the car makes. Oil 2 gave higher wear in some makes than oil 3 and also contained a much higher concentration of zinc dialkyl dithiophosphate than oil 3. This indicates that excessive quantities of this chemical may have an undesirable effect on wear with some metallurgy-design combinations.

4. Oil 2, containing a heavy dosage of zinc dialkyl dithiophosphate, appeared to minimize tappet scuffing severity. In one car group, oil 2 increased cam spalling and provided the greatest resistance to cam scuffing.

5. Oil composition had a marked effect on spalling of chilled cast-iron tappets. The effects differed noticeably, depending on metallurgy-design. For example, oils 2 and 3, which virtually eliminated spalling in cars utilizing steel cams, greatly increased tappet spalling in the cars of a group employing hardened cast-iron cams. The opposite effect was noted with oils 1 and 4.

6. Unhardened cast-iron cams in combination with steel or chilled cast-iron tappets gave negligi-

Continued on page 82

Tests to Insure Proper

AT Chevrolet, results of 8 separate, specific laboratory tests help engineers to design the required stiffness into the car structure. (Other tests are made at General Motors Proving Ground.)

The 8 laboratory tests are: Joint specimen test; center pillar test; door stiffness test; deck-lid stiffness test; car structure bending test; car structure torsion test; slow motion bending and twist test; and determining body-to-frame mounting locations.

Joint Specimen Test

Each joint, such as the junction of the center pillar and roof rail with its important surrounding structure is made up from preliminary drawings, even before the test body is built. Standard attaching plates are welded to the joint specimen to allow the application of test loads.

Specimen test rigs (Fig. 1) then measure deflections of the joint at a standard lever arm length. Test results are compared to previously accepted standards to determine adequacy. Beads, flanges, reinforcements, or spot welds then are added wherever necessary to increase the stiffness to acceptable limits.

Center Pillar Test

Stiffness of the body center pillar is checked by mounting it at simulated body supports, and loading it in the direction of the door slam. Although a center pillar might have a reduced section at the belt, because of exterior styling and interior space requirements, it must still have sufficient stiffness to produce a solid thud, without objectionable flutter, when the door is slammed. Uniform stiffness distribution at the belt is instrumental in eliminating flutter.

Pillar test curves enable the engineer to isolate and correct a localized deflection area by adding a reinforcement or additional welds (Fig. 2). Acceptability of these changes is verified later on a road test car.

Door Stiffness Test

Door lateral stiffness is checked in a rig to discover low seal-pressure areas that might admit water, dust, and drafts, and cause wind noises.

In this test, the door is supported at the hinges and at the door lock location. A lateral load resembling seal pressure is applied to the top of the door in the rig. Deflections are measured around the door periphery and plotted to determine the deflection contour (Fig. 3). The sudden break in the upper curve shown here indicates poor stiffness

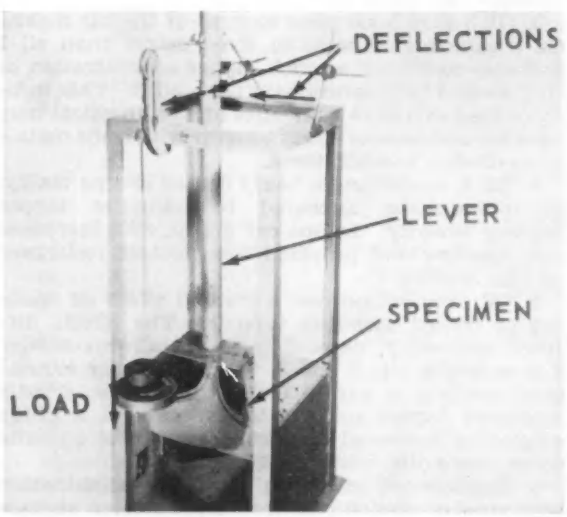


Fig. 1—Deflections of joints are measured in this standard test rig.

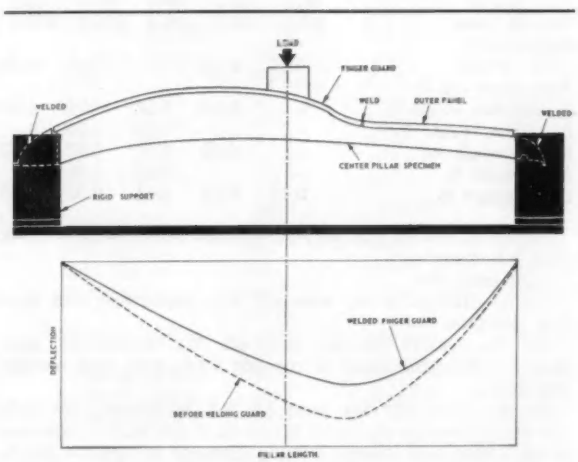


Fig. 2—Lateral stiffness test curves resulting from test of body center pillar specimen.

Stiffness in Car Structure

Based on paper by **G. J. Engelhard,** Chevrolet Motor Division, GMC

distribution. The lower curve shows the increased stiffness and more uniform distribution which resulted from the addition of reinforcement.

Deck Lid Stiffness Test

A typical deck lid torsion test is conducted by mounting the deck lid at its hinges to a buck or body and applying upward loading at one rear corner and downward at the other (Fig. 4). Deflections measured by indicators are used to determine the torsional rate over the length of the deck lid. If the lid has insufficient stiffness, it must be revised and retested. A lid with proper torsional stiffness assures the uniform seal pressure necessary to prevent water and dust leaks.

Car Structure Bending Test

To check bending stiffness of the car structure as a whole, it is supported at points simulating wheel support conditions and a 1500-lb load is applied equally divided between the front and rear seat locations. Vertical deflections are then determined along the entire length of the body and frame, and curves are plotted.

A typical curve (Fig. 5), obtained in this manner, shows the maximum bending deflections as well as the degree of uniformity of bending in both the body and frame and their relationship to each other.

A similar reaction to that shown by the test occurs in a vehicle with a full passenger load as it "squats down" after coming off the rise of a highly crowned intersection or a small hill on a country road. Washboard-type roads also create bending loads in the car structure.

Car Structure Torsion Test

Torsional stiffness is determined, using the same setup, by applying torque at the front wheel locations. Indicators on the body and frame determine

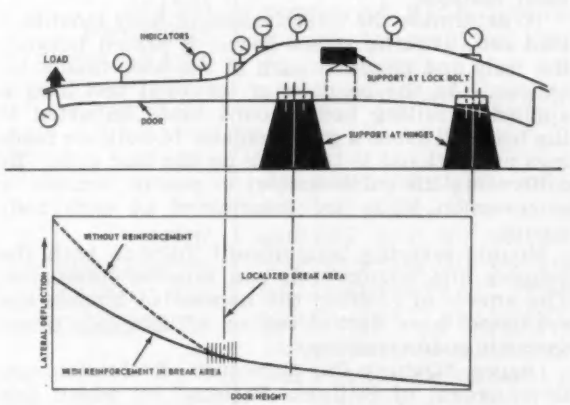


Fig. 3—Door lateral stiffness test—curves resulting from measurements around door periphery are plotted to determine deflection contour.

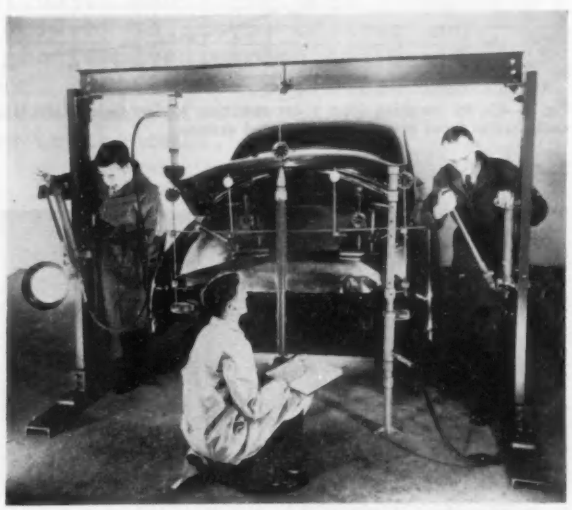


Fig. 4—Rig for testing deck-lid stiffness.

deflections from which degrees of angular twist are established and plotted at various positions along the length of the car structure. Also, rates expressed in terms of pound-feet per degree of twist are computed between significant points on the car structure.

The test engineer compares these rates to those of previously accepted designs and examines the curves for sharp breaks indicating localized deflections (Fig. 6). If the car structure has efficient distribution of stiffness, the curves will be gradual and uniform. The extent to which the body and frame deflection curves follow one another is also observed. Any separation between the curves represents stiffness losses due to inefficient body-to-frame attachments, body shim deflections, chassis outrigger deflections, or body-frame member deflections. A controlled amount of flexibility between the body and frame is often desirable to reduce harshness. Torsion rate curves may also indicate localized bending deficiencies not disclosed in the bending test. Final evaluation of these factors is made during road tests.

Torsional deflections of the car structure occur in everyday driving when a car is turned out of an inclined driveway, driven over rough terrain, or driven over rough roads producing alternate wheel motions.

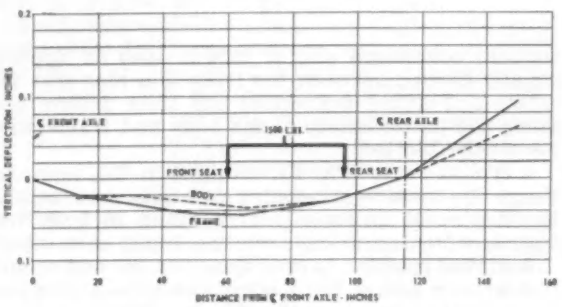


Fig. 5—Deflection curves resulting from car bending test.

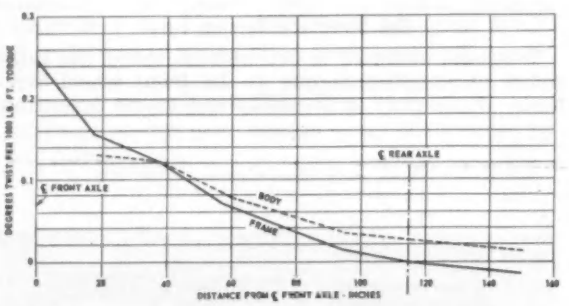


Fig. 6—Curves resulting from a car structure torsion test. Rates are compared to those of previously accepted designs.

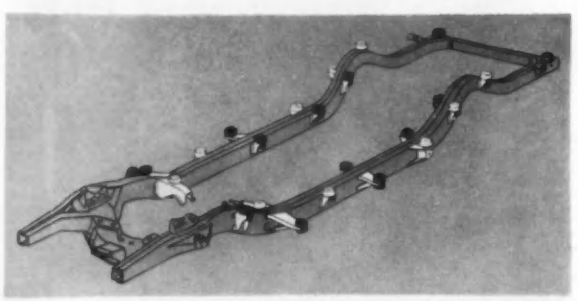


Fig. 7—Unneeded body mounts (light shaded) are eliminated after tests have proved which mounts are necessary.

Slow Motion Bending and Twist Test

The slow motion bending and twist test is performed to evaluate structural changes and to disclose localized deflections in the car structure indicated by the previous static bend and torsion tests. This test is similar to the static bend and torsion test setups, except that it provides visible bending or twisting motions at approximately 100 cpm. It provides the means for observing the action of localized deflections discovered in the static test curves, and establishes their degree of importance. Also, buckling panels, breathing joints, and excessive deflections in the frame and body can be pinpointed. Corrections are improvised and their effectiveness evaluated, after which drawings are revised.

Under forced loading of this type, substantial deflections are expected. It is highly important, however, that deflections have uniform distribution to eliminate localized high stresses.

Determining Body-to-Frame Mount Locations

For exploratory purposes, experimental test cars are often built with more body-to-frame mounts than are actually believed necessary. In a given design, if a mounting is found to be ineffective in carrying loads, its use cannot be justified. Elimination of such body mounts on an experimental test car, identified by light shaded mounts (Fig. 7), was found to reduce the torsional rigidity by only 6% while the maximum bending deflection was increased by only 0.006 in. Road tests run later without these mounts disclosed the rigidity to be within satisfactory limits and the road noise to be substantially reduced.

To determine the effectiveness of body mounts, a load cell, utilizing strain gages, is placed between the body and frame at each of the body mount locations. As the bending or torsional test load is applied, resulting body mount loads imparted to the load cell cause a galvanometer to indicate readings proportional to the loads on the load cells. By calibrating the galvanometer in pounds, tension or compression loads are determined at each body mount.

Mounts carrying insignificant loads in both the bending and torsion tests can thus be eliminated. The effects of altering the number of mounts are evaluated later during tuning adjustments under dynamic road conditions.

(Paper, "Quality Car Structure—Evaluation and Development of Stiffness Factors," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

SAE LOOKS OVERSEAS

by DR. JACQUES POMEY, *Regie Nationale des Usines Renault, France*

NEW HIGH-STRENGTH MALLEABLE IRON

A new type of high-strength malleable iron has been developed at Renault, which, it appears, can be produced by present commercial practice.

This iron has a modulus of elasticity of approximately 26,000,000 psi, a tensile strength of as high as 125,000 psi, an elastic limit of 110,000 psi, and an elongation of 6% or greater. It has impact resistance of 35 ft-lb or greater using the Mesnager specimen which is similar to a Charpy, but with a notch only 2 mm deep. The material has an endurance limit of a minimum of 50,000 psi.

SEVERAL PROCESSES POSSIBLE

The iron is cast white into green sand, or core sand, or permanent mold, or castings can be made by the shell process, or even the lost wax process for small sections. The castings, after being shaken out of the mold, are heated to around 1575 F and quenched in salt at 350 F for 1 min, and then cooled in still air. They are then re-heated to 825 F for about 4 hr, after which they are graphitized by heating to 1650 F for 2 hr and cooling in still air.

MALLEABILIZING PROCESS VERY FAST

This is a very fast malleabilizing process which is made possible by the formation of many very fine graphite nuclei which are produced by this type of treatment, as compared with the coarse tempered carbon ordinarily found in malleable iron. Also, to help produce the many fine nuclei, the iron is denitrided by adding titanium, aluminum, or zirconium to the melt.

FINE GRAPHITE NUCLEI GIVE STRENGTH

To give an idea of the fineness of these graphite nuclei, Dr. Pomey estimates there are 6,000 to 30,000 nuclei per sq mm as viewed under the microscope, as compared with 30 to 150 nuclei per sq mm found in ordinary malleable iron. These fine nuclei contribute to the good mechanical properties. After malleabilizing the part may be quenched or tempered as with steel to get the particular mechanical properties which are desired.

(continued on next page)

This feature is an activity of the SAE OVERSEAS INFORMATION COMMITTEE, C. G. A. Rosen, chairman

SAE LOOKS OVERSEAS

(Continued from preceding page)

CHEMICAL COMPOSITION

The chemical composition of the iron is about the same as ordinary malleable except about 1.25% copper and a little manganese is added. The composition given for one of these irons is as follows:

C - 2.54	P - 0.054
Si - 1.47	Cu - 1.27
Mn - 0.74	Ti - 0.017
S - 0.06	Al - 0.060

AUTOMOTIVE PARTS MADE

Dr. Pomey has made automotive rocker arms, connecting rods, differential cases, and piston rings with this iron. It is further reported that the iron machines very well.

Valve Train Wear—

continued from page 77

ble tappet wear; but most of the wear occurred on the cams. With all other combinations the average tappet wear was approximately the same as the average cam wear. However, where individual tappets showed high wear the contacting cam did not necessarily do so, and vice versa.

7. In combination with hardened cast-iron cams, chilled cast-iron or steel tappets showed considerably more wear than hardened cast-iron tappets with oils 1 and 4 in cars 2, 6, 8, and 9.

8. Only chilled cast-iron tappets showed an appreciable spalling tendency. With these tappets some spalling occurred with all types of cams tested, but was least prevalent with unhardened cast-iron cams. In one make, where three types of chilled cast-iron tappets were distributed evenly among the cams, one type was significantly superior to the other two.

9. Appreciable cam spalling was observed only with unhardened cast-iron cams and was more severe with steel than with chilled cast-iron tappets. With these combinations the cam spalling was accompanied by a slight increase in cam wear but had no effect on tappet wear. The effect of oil composition on cam wear can be greater than the effect on cam spalling, as evidenced by the fact that the cams of make 12 showing medium spalling with one oil wore less than the unspalled cams with another oil.

10. Tappet scuffing is more dependent on metallurgy-design than on oil composition. Only one make evidenced tappet scuffing to a serious degree, but the scuffing appeared to cause no objectionable cam distress.

11. In car make 1, designed to prevent rotation of tappets, nonrotating tappets gave the least cam and tappet wear. Nonrotation was usually associated with the greatest scuffing tendency in these cars and spalling tendency was greatest for rotating tappets.

12. Most cars in the survey were operated in mixed long and short trip service and no clearcut effect of type of driving could be detected. As a result, it is concluded that type of driving should not affect the conclusions reached above. Results in controlled tests with four cars of make 1 indicate higher wear for two cars operated exclusively on short trips than for two identical cars operated exclusively in high-speed service.

13. There were indications that tappet spalling tendency was related to the rate of wear. In general, a reduction in wear rate was associated with increased spalling tendency. This effect was most clearcut among designs where the wear was sensitive to oil composition.

14. Cam scuffing was not a widespread problem. It occurred to a limited extent in certain combinations of oil and metallurgy-design. When observed, it was generally associated with a many-fold increase in cam and tappet wear.

Cruise Control System Proposed for Jet Aircraft

Excerpts from paper by **H. F. Kidder,** Minneapolis-Honeywell Regulator Co.

AN INTEGRATED display of cruise data is proposed to help the pilot make best use of his fuel supply on a given flight. Cruise data displays of optimum altitude, Mach number, and engine pressure ratio could easily be integrated into the cockpit instruments already showing these parameters. Maximum range, having no counterpart, would necessarily have to be obtained from an added instrument. Then an airborne computer of reasonable size and weight could be used to deliver the data needed for such cruise control.

Since integrated instrumentation is tailored to the category and principal mission of a specific aircraft, a multiengine, Mach-limited, medium-range aircraft with a small crew will be assumed.

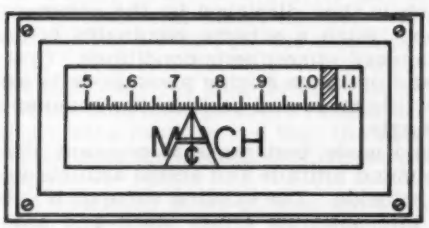


Fig. 1—Mach indicator.

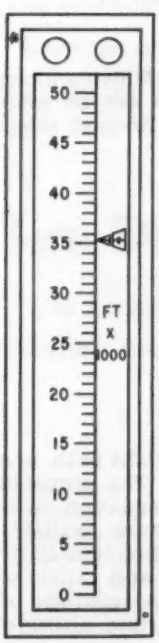


Fig. 2—Gross altitude display.

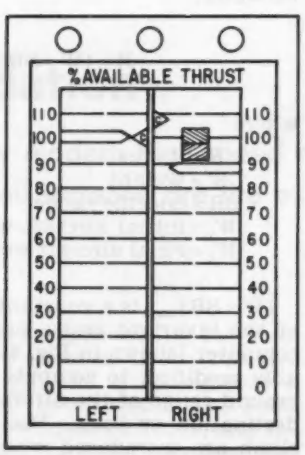


Fig. 3—Engine performance indicator.

Mach Display

The Mach indicator is shown in Fig. 1. Tests show that horizontal-scale speed indication is best from a human engineering standpoint. The device used here is a modification of an indicator we are developing for an operational aircraft. The apex of the split triangle pointer indicates actual Mach number, while the trapezoidal section with the "C" on it is used to indicate command or optimum Mach. The scale is easily readable to 0.01 Mach and provisions are made in the cruise data computer to expand the actual Mach, optimum Mach difference so as to produce a vernier effect, if desired.

Altitude Display

The altitude display for the proposed system is shown in Fig. 2. It is a servo-driven indicator with indices similar to those of the Mach indicator. Obviously, this does not present enough information to control the plane in all phases of flight. Rate of climb and low-altitude high-resolution altimeter displays are necessary, but are not part of the cruise control problem.

Engine Performance Display

A 2-channel engine performance indicator is shown in Fig. 3. It displays per cent available thrust

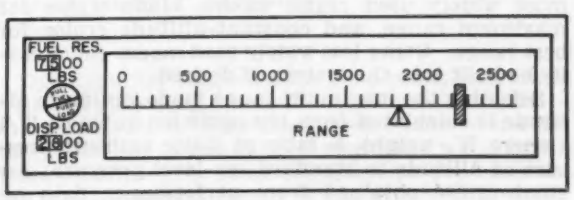


Fig. 4—Range indicator.

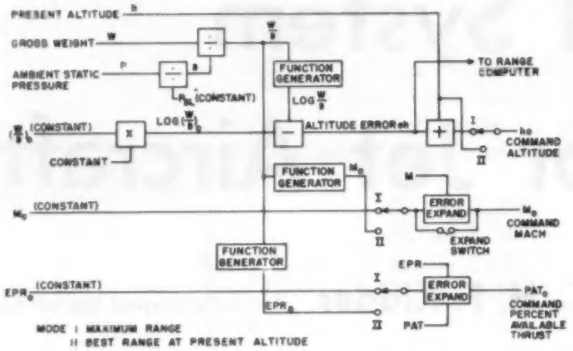


Fig. 5—Cruise data computer-block diagram.

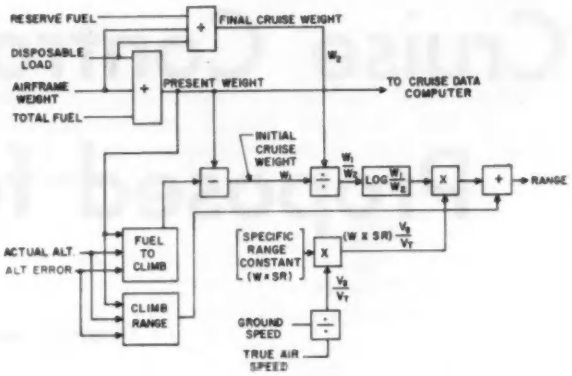


Fig. 6—Maximum range computation.

based on engine pressure ratio and turbine inlet air temperature. Actual per cent thrust is indicated by the two outer indices, while command or optimum functions are at the center. Time-limited operation and danger warnings are displayed at the center of each section. The command indices also operate on the expanded scale principle.

In this instance, to derive the proper command functions in terms of engine pressure ratio alone, the difference between the actual and the desired pressure ratio is multiplied by some scale expansion factor and then added to the actual per cent thrust indication. The sum is then used to position the command index.

This type of indication has the advantage that if all engines are operating at the thrust specified by the command indicators, a straight, horizontal line is established.

Range Display

The range indicator proposed for the cruise control system is shown in Fig. 4. The left edge of the striped bar indicates maximum available ground range, not including the use of reserve fuel. The triangular index is coupled to a suitable navigation system and indicates ground miles to destination. Fuel reserves and disposable load inputs are provided to the left of the range scale.

Cruise Data Computation

A simple computer for generating cruise data is shown in Fig. 5. Its outputs are signals actuating the command indices in the Mach, altitude, and engine performance indicators. The circuits shown will compute the necessary data for defining the two most widely used cruise modes, climb-cruise for maximum range, and constant-altitude cruise for best range. Other less widely used modes could easily be built into the system, if desired.

Selecting the maximum-range mode, optimum altitude is calculated from the optimum value of W/δ (where W = weight, δ = ratio of static ambient pressure at altitude to standard sea-level pressure) for climb-cruise obtained from performance data on aircraft and stored in the computer. The value of W/δ existing at the present weight and altitude of aircraft is compared to the stored optimum value and the difference transformed into an altitude error in feet. This is then added algebraically to the existing altitude to obtain the optimum or command altitude, which is then displayed by the command altitude index. Such a scheme eliminates errors due to nonstandard atmospheric conditions. Optimum Mach and optimum engine pressure ratio are constants for this mode and position the command indices acordingly.

In the second mode, best range at constant altitude, the command altitude and actual altitude indices always coincide. The existing value of W/δ is transformed into optimum cruise Mach and optimum engine pressure ratio using smoothed performance data stored in function generators.

Range Computation

The range of a Mach-limited aircraft flying along its optimum climb-cruise flight path can be computed from a modified form of the Breguet range equation:

$$R = (W \times \mathrm{SR})_{\max} \log \frac{W_1}{W_2}$$

where:

R = Range
W = Weight
SR = Specific range
W_1 = Initial aircraft weight
W_2 = Final aircraft weight

$(W \times \mathrm{SR})_{\max}$ is a constant for this flight path, one of the invariant cruise parameters. The proposed computer (shown in Fig. 6) uses this equation, suitably modified, to compute the maximum available ground range of the aircraft in the direction of its destination or base. Fuel to climb and range in climb are introduced when the actual altitude of the aircraft is below its optimum cruise altitude.

Descent fuel or range is not considered nor is the range equivalent of excess total energy. In applications where these become important, they can be added to the basic system. Air range is converted to ground range in the direction of the base by applying a range factor derived in the navigation system from suitable wind data.

In some instances, it may be desirable actually to compute the range parameter $(W \times SR)_{max}$ using measured fuel flow and true airspeed instead of relying on stored data. This, of course, would only be meaningful when the aircraft is operating at steady-state conditions on its cruise flight path.

System Operation

The cruise control data presented by this system will allow the pilot of the aircraft quickly and easily to establish the conditions for maximum range or for best range at constant altitude. If maximum range is desired, the pilot places the cruise mode selector switch in the proper position and checks his deviation from optimum altitude. Assuming this is more than a few thousand feet, the pilot will execute a standard climb and level off at the altitude shown by the command altitude index. The per cent available thrust is then adjusted with the throttle, until the command value is obtained. Then, using elevator control, the aircraft is trimmed to the command Mach number. This procedure will put the aircraft on the maximum-range flight path. In flight, holding the aircraft at optimum Mach number for long periods is a tedious job. If a Mach hold auto-pilot is available on the aircraft, cruise data could be fed into the autopilot to keep the aircraft on the optimum flight path automatically.

If maximum range at constant altitude were desired, operation would be somewhat different in that the optimum Mach number and required thrust generally decrease as the weight of the aircraft decreases, requiring frequent throttle adjustments.

While the cruise data system tells the pilot how to fly the maximum range flight path, the range system indicates how far he can travel along this path with his remaining fuel. If the aircraft is not at optimum altitude, the computer calculates maximum range on the assumption that it will immediately climb to optimum cruise altitude in some standard manner. Finally, the system compares the range capability of the aircraft to the range required by the tactic to which it is committed. In practice, the pilot would store in his navigation system the coordinates of his destination and appropriate wind data. This would automatically position the range-to-go index in the range display. Disposable load and desired fuel reserve over the destination would be manually entered, also. While airborne, the pilot would monitor the range instrument at regular intervals.

On normal cross-country flights, both range indications would decrease uniformly as the aircraft traveled toward its destination. However, if conditions beyond the scope of the range computer existed, such as unanticipated adverse winds or fuel siphoning, the spacing between the indices would close. A tactical emergency would be indicated when they overlapped. In this respect, the range system would function as a mechanized flight progress chart.

On patrol flights, the device would tell the pilot when to return to the base.

The accuracy of programmed cruise control systems depends on how well the data stored in the system describes the particular aircraft in question. Assuming proper maintenance, it is believed that the errors due to this factor will be small.

In addition to the range and cruise control data presented by the integrated system, it would be necessary to provide the pilot with instructions or data for dealing with the common in-flight emergencies such as engine-out performance, low altitude, low fuel procedures for best range, maximum range descents, and very high winds at cruise altitude. These data should be presented in as simple and straightforward a manner as possible.

(Paper, "Cruise Control Instrumentation for Turbojet Aircraft," on which this article is based is available in full in multilith form from SAE Special Publication, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members; 60¢ to nonmembers.)

Tire Degradation . . .

. . . is accelerated by modern high-speed driving. Use of larger size tires and higher inflation pressures will increase tire life expectancy.

Based on paper by **M. P. Hershey,** Firestone Tire & Rubber Co.

HIGH heat generated by today's racing-car road speeds has a degrading effect on tires. The tire makers' solution to the problem is to engineer a product designed especially to withstand such deterioration, but the use of adequate size tires, and increased inflation pressures to reduce flexing and heat buildup, are essential for good tire life.

Open country coupled with good roads encourage high-speed driving. This is reflected in tire adjustment data which show that drivers tend to use all the power and speed at their command when highways permit. 81% of all adjustments are made in the Southwest and Middle West, where 43% of the nation's cars are registered, whereas only 6% arise

in the Northeast where 32% of the cars are located.

The higher the speed the more rapid the tire flexing and the greater the heat buildup, with consequent deterioration. At maximum load and 24-psi inflation, the tread temperature of a 7.50-14 size tire at 70 mph is 215 F. At 100 mph it rises to 274 F. Maintaining tire running temperatures in the 250–270 F range for an extended period of time causes a loss in tire properties and can result in tread chunking or a separation condition. Between 100 and 250 F, the compounds lose 40% of their tensile strength. Most of the initial properties are recovered after short exposure to high temperature, but long exposure gives permanent degredation.

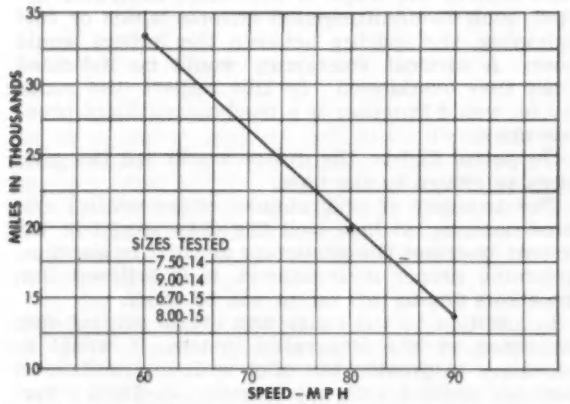


Fig. 1—Continuous high-speed travel shortens tire life. Under a given set of conditions, a tread life of 33,000 miles at 60 mph drops to 14,000 miles at 90 mph.

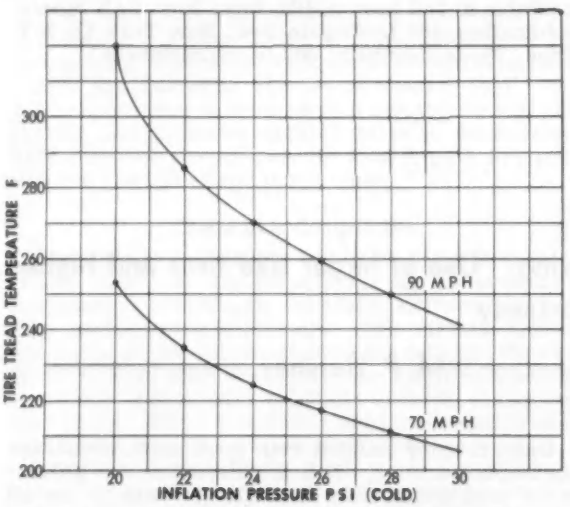


Fig. 2—Effect of inflation pressure on temperature shows need for adequate pressures since high heat is destructive of tires.

Excessive load also has a bad effect. The difference between a load of 1085 and 1300 lb at 80 mph is a temperature increase of 25 F; at 100 mph the differential is 38 F. The high load in effect reduces the speed capability of the tire by 10 to 15 mph.

Adhesion of tire tread to cord body is also reduced with maintained exposure to high operating temperature. At 10,000 miles the adhesion value has dropped to 75% and at 30,000 miles it is only 55%, measured at 250 F.

Fig. 1 illustrates the reduction in tires life expectancy at continuous high speeds. Given a set of conditions and 60 mph, tread life will be 33,000 miles; at 80 mph the mileage drops to 20,000 miles, while at 90 mph it is only 14,000 miles.

Essentials for High Speed

For a given load, best high-speed performance will be obtained with a tire as large as is practical to use. Tests show that if 7.50-14 and 8.00-14 tires are run at the maximum load assigned to the larger size tire, the 7.50-14 tire will have only 67% of the durability of the larger size one at speeds up to 95 mph. With a given load and given size tire, service at 60 mph may be entirely adequate, but be entirely inadequate at 80 or 90 mph.

Inflation pressure is another critical factor. Fig. 2 shows how tire tread temperature can be lowered by increasing pressure. At 70 mph, an increase from 22 to 28 psi lowers the temperature of a 7.50-14 tire by 23 F; at 90 mph the drop is 35 F, and this would make the difference between satisfactory service and premature failure.

Features of High-Speed Tires

The new Firestone "500" high-performance tire features nylon cord body construction and high adhesion compounds. There are three reasons for using nylon: (1) It is lighter in gage but stronger than other cords. Reduction in weight and bulk makes for cool running. (2) It is very resilient and efficient. It builds up less heat during flexing. (3) Its shrinkage tendency when hot. This constricts the tread center circumferentially and the tire maintains a wider contact width with the road, which distributes the stresses more uniformly throughout the tire.

Racing-Type Tire

Another tire, the "Super Sports 170," has a racing-type, 6-ply nylon cord body for light weight, extremely high strength, and cool running. The compounds used in the cord body give excellent adhesion between plies plus low heat generation. Tread distortion has been minimized in this tire. This distortion or traction wave condition starts to appear in a conventional passenger-car tire at 90–100 mph and becomes progressively worse at higher speeds. The tread elements passing through a severe wave condition are under great stress and the heat generated will cause the tread to crack and chunk out, or to separate from the cord body.

(Paper, "Tires for High Speed Operation," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

WANTED:

A Realistic Industrial Readiness Program

Excerpts from secretary's report by **Loyd C. Smith,** General Electric Co.

THE traditional industrial mobilization planning concepts generated out of World War II experience are seriously unrealistic in today's situation. There will be neither time nor capability to build forces, with which to win a war, after the outbreak of a general war. Instead we must maintain modern ready forces in-being, so that we may deter such a conflict, defend against it if it does come, and retaliate with devastating severity.

Realistic industrial planning must recognize that sustained production of complex equipment after a nuclear attack would be highly questionable, because of the tremendous damage that would occur to vital segments of our interdependent and sprawling industrial structure. Final assembly plants, that would remain operational, could complete assembly of equipment only from resources actually on hand. Projects are now in effect which would produce maximum quantities, after an attack, from previously expanded inventories, but only to supplement our forces during the first critical weeks of conflict. These are referred to in the Air Force as Production Compression Capability, or PCC projects.

Beyond this initial period, there would be a herculean task of reprogramming the surviving capacity, or of rebuilding capacity, before any significant production of complex equipment could be realized. Engines could be assembled almost anywhere and tested outdoors. But airframes, which require complicated and costly jigs and other production facilities, could not be built under such make-shift arrangements. Reprogramming and rebuilding would be a long term matter under such conditions and would probably have little affect on the ultimate outcome of the conflict.

In the case of local or peripheral wars, there must be a capability for rapidly accelerated production of vital equipment to replace attrition of our in-being forces committed to such a conflict. In a local war situation, industrial damage would be limited to possible sabotage and sustained acceleration of production would be feasible. For selected equipment, projects have already been developed for rapidly accelerating production, using the Production Acceleration Capability (PAC) concept. Normal production acceleration would be required for other items consumed, but not on the scale of previous wars.

The Air Force's basic program for industrial readiness is called "The Industrial Production Readiness Policy and Program." This program has resulted in significant changes in industrial planning. Air Force planning has been up-dated realistically to meet today's situation and is now compatible with operational and war-planning concepts. This planning is based almost entirely on the in-being active production base. Paper planning and lay-away or conversion type industrial capacity is being de-emphasized. Planning is now on a highly selective basis, tailored to achieve the most realistic readiness possible and to conserve resources.

The Navy concept of industrial readiness has not changed as radically as has that of the Air Force. Of course, there are considerably different circumstances. The long lead times for major marine equipment for the Bureau of Ships does not permit programs such as the PCC or PAC. Greater attention must be dedicated to the creation, modernization, and flexibility of forces in-being. Production facilities, such as a shipyard, cannot be quickly replaced and secondary or alternate sources for large components are not practical.

The Navy must have more flexibility in the missions for their equipment than is permitted under Air Force concepts. Plans in-being anticipate either atomic or peripheral wars, with alternate missions to meet any emergency. A carrier, for instance, could be used for evacuation, not only of

SERVING on the Industrial Readiness Panel were:

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J. D. Wethe, Manager, Marketing, Production Engine Department, General Electric Co.

Panel Secretary

L. C. Smith, Manager, Industrial Readiness Programming, Production Engine Department, General Electric Co.

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Warner Newby, Col., USAF, Chief, Industrial Readiness Division, Headquarters

C. L. Monroe, Col., USAF, Chief, Industrial Resources Division, Headquarters, AMC

Gifford Meyers, Chief, Military Sales, Georgia Division, Lockheed Aircraft Corp.

P. N. Jansen, Special Assistant to Senior Vice President, Boeing Airplane Co.

R. H. Maynard, Capt., Head, Industrial Mobilization Planning Branch, Office of Naval Materiel

D. M. McGrath, Plant Manager, Solar Aircraft Co.

military but of civilian personnel in foreign lands.

Concepts for production planning of aeronautical equipment, as stated by Navy representatives, indicate that future mobilization and readiness policies would be closely comparable to those recently adopted by the Air Force.

Under the Air Force philosophy of developing and maintaining a production base, the introduction of new weapons into the Air Force inventory would require a re-evaluation of past policies and practices. As the expenditures for aircraft are gradually decreased, there will be a corresponding increase and expenditure for missiles. This will mean that fewer end items of hardware will be bought, but each end item or weapon system will be more effective than its predecessor.

Along with fewer end items, there will be no long production runs. Consequently, many present facilities may become idle. This condition will require a re-evaluation of the present sub-contracting policy with a possible change in the degree of sub-contracting in future programs.

New weapons will require the introduction of new materials, which in turn will necessitate new production processes and techniques. These complicated processes and techniques, which will require tremendous developments in skills and facilities, will affect the capability of the prime contractor to complete his end item. That would require much too costly a duplication of skills and facilities. As a direct result, the specialized component and subsystem industry must be brought into the picture to a greater degree than at present.

Basic industry must be kept aware of future requirements so that,

1. the state of the art may keep pace with the designers needs and,
2. the final processing be within the capability to produce.

The development of a production base must start with the cooperative efforts of the designer and the producer, working toward production of a satisfactory functional weapon. Maintaining that base is contingent upon the mutual trust and respect shown toward each other.

This report together with other panel reports is available as SP-319 from SAE Special Publications, 485 Lexington Ave., New York 17, N.Y. Price: $1.50 to members; $3.00 to nonmembers.)

A Good Preventive Maintenance Program . . .

. . . will likely pay back, in increased vehicle life, all the dollars put into the program. Here is the hypothetical but realistic study of the cost and economic value of such a program.

Based on paper by **W. J. Corr,** Mack Trucks, Inc.

LET us assume that we have a truck that operates 75,000 miles per year in long distance service. The truck has a gross weight of 60,000 lb, is powered by a diesel engine, has a 10-speed transmission or a 5-speed transmission, with a 2-speed axle or a conventional rear axle, and uses 10.00 × 22 tires. In other words, our hypothetical vehicle is one of the usual vehicles encountered on the road today.

All preventive maintenance programs break down into two basic phases:

1. Lubrication
2. Minor mechanical adjustments and repairs

These programs are usually based on operational factors of either time, or miles, or both.

In the case of our hypothetical vehicle, the manufacturer's recommendation is that the truck be lubricated each 2000 miles, the engine oil changed each 4000 miles, and the gear oil changed semian-

nually. So the lubrication labor costs will break down approximately as follows:

Lubrication Labor Costs

Operation	Frequency In Miles	No. of Times	Operation Labor Hours	Total Annual Hours
Chassis Lubrication	2000	37	0.7	25.9
Engine Oil Change	4000	18	0.2	3.6
Gear Oil Change	37500	2	0.2	0.4
Total Labor Hours				29.9

The labor cost will vary with each operator, but a fairly conservative figure would be $2.00 per hr for the direct labor charge. So the annual labor cost for lubrication would be $59.80 per year.

Now we must consider the cost of the lubricants. The following table gives a fair estimate of these costs.

Cost of Lubricants and Associated Miscellaneous Charges

	Required Amount	Cost per Unit	Cost per Change	No. of Changes	Total Annual Cost
Engine Oil	24 qt	$0.20	$4.80	18	$86.40
Gear Oil	55 pt	.15	8.25	12	16.50
Chassis Lubricant	2 lb	.20	.40	37	14.80
Make-Up Engine Oil (at rate of 300 miles per qt)	200 qt	.20			40.00
Gear Lubricant Make-Up	25 qt	.15			3.75
Wheel Bearing and Other Special Lubricants					5.00
Engine Filter Elements		2.50	2.50	18	45.00
Miscellaneous					3.00
Total Cost of Lubricating Material					$214.45

The total annual cost for the complete preventive maintenance lubrication is $274.25 ($59.80 for labor and $214.45 for lubricating material). This works out to a cost of .0036¢ per mile.

Having set up the cost for lubrication, the next step is to calculate the cost of doing the minor mechanical adjustments and repairs. These operations are usually set up on the basis of light, medium, and heavy inspections on a regular rotating basis. Usually, the preventive maintenance mechanical inspections are tied in with the lubricating periods.

The light-inspection schedule calls for a quick check of battery level, coolant level, wiper motors and blades, lights, signal instruments, tires, draining air tanks, and checking of minor items reported by the driver that may require adjustment or minor repair. The lubrication job is done at 2000 mile intervals, so the light inspection should be done at the same time. The average time required to do the specified operations is one hour.

The medium inspection includes checks and minor adjustments on electrical systems, fuel systems, clutch, brakes, drive-line bolts, spring clips, cab hold downs, fan belts, and fenders. Both the light and medium checks are largely visual. There are some items that do require actual contact of tools on assemblies, but the required time is short. This inspection and adjustment will take about 2.5 man-hours. This check should be performed each 4,000 miles of operation and tie in with engine oil change periods.

The heavy-inspection schedule provides a very complete overall check and includes the operations covered by the other two schedules. Additional items covered are: repacking of wheel bearings, examination of brake drums and linings, exhaust system, and brake units. This inspection should be performed at 24,000 mile intervals. The time required will approximate 15 man-hours.

The following chart shows the approximate labor cost per year:

Inspection Schedule—Labor Cost

	No.	Hours	Total Hours	Labor Rate	Cost
Light Inspections	19	1	19	$2.00	$ 38.00
Medium Inspections	16	2.5	40	2.00	80.00
Heavy Inspections	3	15	45	2.00	90.00
Total Labor Cost					$208.00

As in the case of lubrication, material will be required to carry out minor repairs. Actual experience has shown that a reasonable allowance is:

Cost of Minor Repairs

	Allowance	No. of Operations	Total
Light Inspection	$ 1.00	19	$ 19.00
Medium Inspection	3.00	16	48.00
Heavy Inspection	20.00	3	60.00
Total Material Cost			$127.00

The total annual cost of the mechanical preventive schedules is $335 ($208 for labor and $127 for material). This figures out to a cost of .0045¢ per mile. The combined total cost of lubrication and minor repairs works out to $609.25 or .00825¢ per mile.

Now let us consider the relationship of preventive maintenance cost to overall maintenance cost by projecting both charges for a 5-yr period. At the end of the 5-yr period our vehicle will have accumulated approximately 350,000 miles. The average cost of total maintenance will be approximately .03¢ per mile, if the labor rate is $2.00 per hour, or a total maintenance cost of approximately $10,500. The preventive maintenance program outlined above would represent a total 5-yr cost of $3046.25 which would provide $7453.75 for major repair maintenance. So our preventive maintenance is costing 29% of the total maintenance cost.

A good preventive maintenance program will extend the useful life of a vehicle from 25% to 100% and this kind of a "stretchout" is the one factor that gives the operator the opportunity of reducing the $7453.75 repair cost allowance to a point where the actual repair costs approximate the cost of the preventive maintenance program. In other words, the dividend received from a good preventive maintenance program can be a saving of all the dollars that were put into it.

(Paper, "The Economics of Preventive Maintenance Applied to Motor Trucks" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Small Turbojets Suit Mach 2-3 Range at 50,000-70,000 ft Altitudes

Based on paper by

Reece V. Hensley, Stanley R. Shapiro, and Raymond Capiaux

Turbomotor Division, Curtiss-Wright Corp.

ANALYSIS shows that small turbojets producing 2000-lb thrust are suitable for the Mach number range of 2–3 and cruising altitudes of 50,000–70,000 ft. This is the speed-altitude environment foreseen for the next generation of turbojets.

The so-called "3/2 power law" assumes that in two physically similar engines of the same aerodynamic and thermodynamic design the air handling capacity and therefore the thrust varies as the frontal area (or the square of a linear dimension) whereas the volume and weight vary as the cube of a linear dimension. Therefore the specific weight would vary as the 3/2 power of the engine diameter.

A more realistic approach to the evaluation of the relative merits of small and large engines is the comparison of actual engine designs covering a range of sizes. A prodigious amount of work is involved in this undertaking if any worthwhile conclusions are to be expected. Relatively thorough designs are required and the size range to be covered is greater than that normally investigated with the required thoroughness by an individual engine manufacturer. A practical solution to this difficulty is the comparison of data from different sources that specialize in engines covering the desired size spectrum. The purpose of our analysis was to provide such data for the small-scale engine.

Our analytical data, presented in Figs. 2–7, indicate that the turbojet engine for Mach 2–3 missions at 50,000–70,000-ft altitudes should incorporate:

1. Sea level pressure ratio of 4 to 7.

2. Uncooled turbine operating at currently attainable temperatures for long ranges at Mach numbers up to approximately 3.0.

3. Afterburning or turbine cooling for short ranges and for Mach numbers greater than 2.5.

These particular characteristics are fortunate insofar as the small gas turbine is concerned. These features can be obtained in small scale engines of relatively simple, straight-forward design, without the necessity of sacrificing performance, yet retaining a significant weight advantage over large engines.

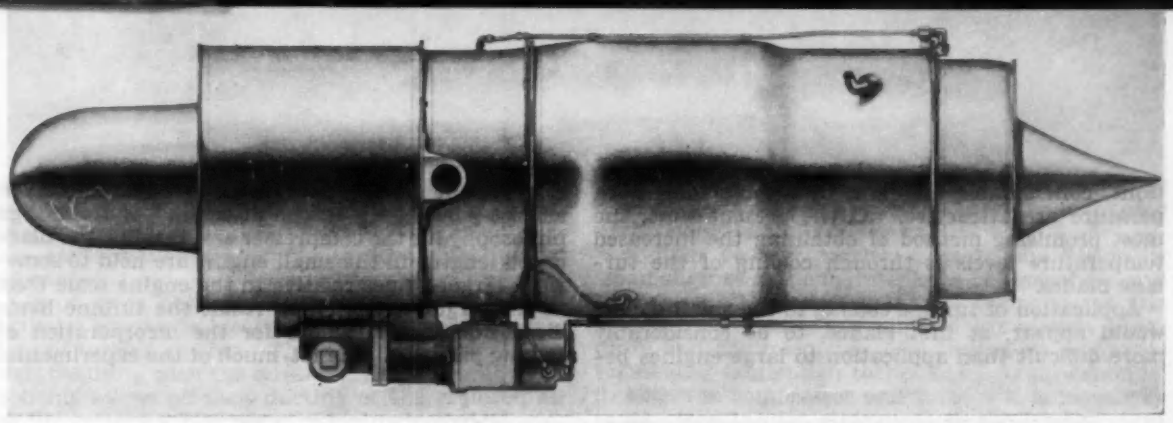
One of the major factors contributing to the simultaneous attainment of low specific weight and excellent performance in small engines is the significant progress in the past several years in the attainment of high stage pressure ratios in both compressor and turbine blading. By utilizing high relative velocities with conservative loading it is now possible to design five-stage compressors having over-all total pressure ratios of 4 to 7.

Because of the small number of stages, individual blade chords can be maintained at higher values than would be practical if many more stages were used. These larger chords provide higher Reynolds numbers, and therefore retain high efficiency at high altitudes.

In the turbine, a similar situation exists. By using high relative velocities, a single stage turbine can provide the necessary power for the compressor of pressure ratio 4 to 7, with an obvious saving in weight when compared with a two-stage turbine. As in the compressor, by minimizing the number of stages, turbine blade chord lengths can be retained at values high enough to preclude serious performance decay due to Reynolds number effects.

A second advantage derived from using high relative velocities in the turbine is a reduction in the weight of an individual turbine stage. The higher relative velocities provide a lower blade height or annulus area. As the blade stress is a function of the annulus area, and sufficient disc material must be provided to accommodate the blade forces, this reduction in annulus area results in a lighter turbine rotor stage.

As was shown in the analysis from which data in Figs. 1–7 were derived, the unaugmented turbojet engine operating in the range of currently attainable turbine inlet temperatures offers excellent performance potential at Mach numbers up to approximately 3.0. However, for short ranges at these Mach numbers and for the higher Mach number applica-



SMALL TURBOJET ENGINE designed essentially for Mach 2-3 speeds at 50,000-70,000 ft altitudes incorporates a five-stage compressor, a single-stage uncooled turbine, and a conservative combustion chamber operating at a temperature in the currently attainable range. The engine produces 2000 lb thrust at a specific fuel consumption considerably below 1.0. The total weight including the control is 170 lb. (Or, the thrust-to-weight ratio is approximately 12.) The unaugmented performance characteristics are excellent up to Mach numbers beyond 2.5. Actually, the engine is conservatively designed, in that stress levels throughout are well within currently established limits, and the entire aerodynamic and thermodynamic design is based on already proven concepts.

For the Purposes of this Analysis . . .

Assumptions

Cruise Mach Number	***2.0***	***2.5***	***3.0***
Initial Altitude, ft	***50,000***	***60,000***	***70,000***
Cruise Lift-Drag Ratio	***5***	***4***	***3.25***
Inlet Pressure Recovery	***0.91***	***0.85***	***0.75***

The lift-drag ratio of the vehicle and the engine thermodynamic performance were kept constant, with a resultant gain in altitude such that the vehicle was cruising along a Breguet path. The climb angle was found to be extremely small and it was therefore assumed that the lift-drag ratio was equal to the ratio of the vehicle weight to the engine net thrust.

The component efficiencies and other parameters assumed are representative of those currently attainable. The inlet pressure recovery values are considered representative of annular inlet engine installations. For the afterburning engine, the turbine inlet temperature was taken to be 2160 R with an afterburning temperature of 3700 R. For the nonafterburning engine, the temperatures were taken successively to be 2160, 2460, and 2760 R. The latter two temperatures are ordinarily not attainable without provisions for turbine cooling. Therefore an appropriate amount of air bled off from an intermediate station in the compressor was allowed for turbine cooling. The air bleed ratio was, of course, varied with flight Mach number as well as with turbine inlet temperature. A fully expanding jet nozzle with a thrust coefficient varying between 0.95 and 0.97 was assumed. The major remaining thermodynamic variable is, therefore, the compressor pressure ratio which was varied from 3 to 13 at sea level static conditions.

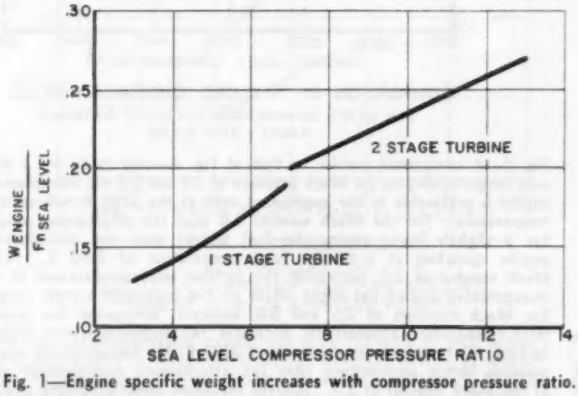


Fig. 1—Engine specific weight increases with compressor pressure ratio.

The engine specific weight was scheduled as a function of the sea level compressor pressure ratio. The base specific weight variation is shown in Fig. 1. The curve shown is for a turbine inlet temperature of approximately 2160 R. For the higher temperatures investigated the specific weight was adjusted to reflect the increased output for a given engine mass flow and the structural weight increase required to accommodate turbine cooling.

The specific weights shown are representative of modern engines in the medium-to-high thrust category. In the analysis the specific weight was increased by 20% to allow for the afterburner where applicable.

tions, considerable increases in turbine inlet temperature are attractive. At the present time, the most promising method of obtaining the increased temperature levels is through cooling of the turbine blades.

Application of turbine cooling to the small engine would appear, at first glance, to be considerably more difficult than application to large engines because of the smaller blade cross-sections. However, as just pointed out in the discussion of the design philosophy for the compressor and turbine, the blade chord lengths in the small engine are held to somewhat larger values relative to the engine scale than in the large engine. As a result the turbine blade dimensions are adequate for the incorporation of cooling passages. In fact, much of the experimental

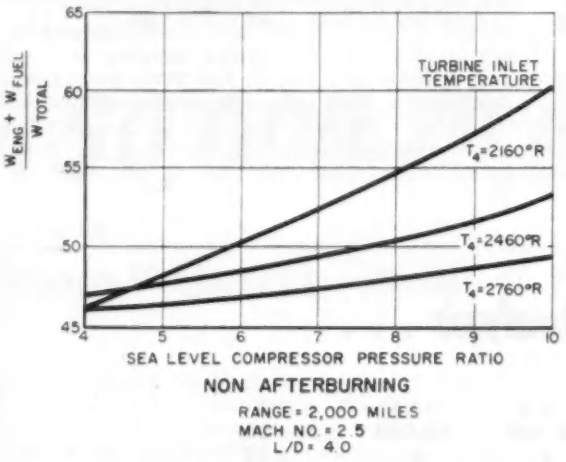


Fig. 2—Ratio of propulsion system weight to vehicle weight for non-afterburning turbojet increases with compressor pressure ratio. For a Mach number of 2.5, it is desirable from a payload viewpoint to have the sea level compressor pressure ratio in the range of 4 to 7. Slightly lower engine-plus-fuel weights would occur at pressure ratios lower than 4. However, at least two major disadvantages to such lower pressure ratios exist: First, the specific thrust at take-off and during acceleration through the transonic region is considerably less than for somewhat higher pressure ratios; and second, the higher pressure ratios make possible a much more compact and lower frontal area combustion chamber and afterburner.

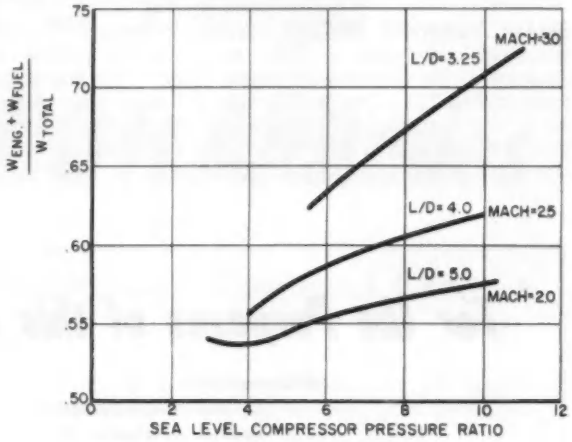


Fig. 3—Ratio of propulsion system weight to vehicle weight with afterburning increases with compressor pressure ratio. As with nonafterburning turbojet, for a high pressure ratio machine the specific fuel consumption at altitude is low but the specific weight is high, thereby resulting in a high weight of engine plus fuel. As the pressure ratio is lowered, the specific weight of the turbojet improves with a relatively small increase in specific fuel consumption. As a result a minimum value of engine-plus-fuel weight is obtained at a relatively low pressure ratio.

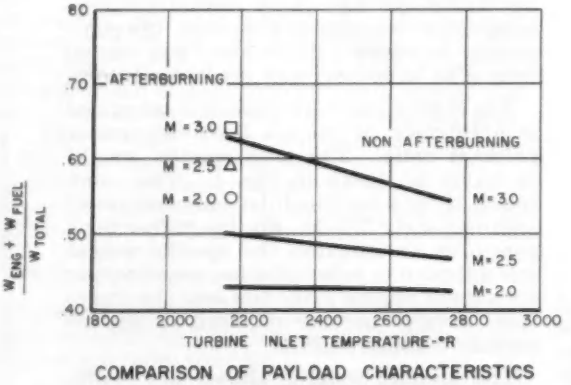


Fig. 4—Comparison of the unaugmented and afterburning performance indicates that for the 2000-mile range the unaugmented engine is preferable to the afterburning configuration. At the Mach numbers of 2 and 2.5 only slight improvement is obtained by increasing the turbine inlet temperature above 2160 R. At Mach number 3 however, considerable improvement results at the higher turbine inlet temperatures.

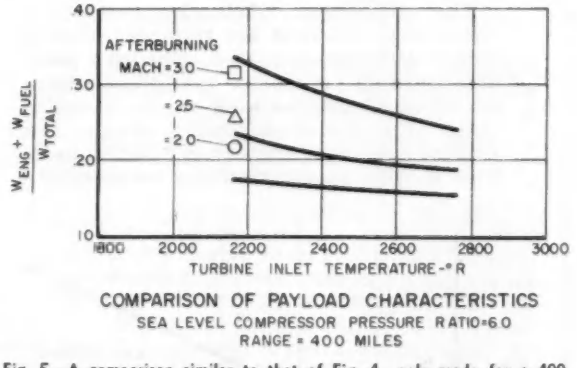


Fig. 5—A comparison similar to that of Fig. 4—only made for a 400-mile range—indicates for Mach numbers of 2.0 and 2.5 the unaugmented engine is preferable to the augmented even at the 2160 R turbine inlet temperature. For the Mach number 3.0 case the afterburning engine has a slightly lower engine-plus-fuel weight than the unaugmented engine operating at a turbine inlet temperature of 2160 R. For a Mach number of 2.0, increasing the turbine inlet temperature of the unaugmented engine has slight effect on the propulsion system weight. For Mach numbers of 2.5 and 3.0, however, increasing the turbine inlet temperature substantially decreases the engine-plus-fuel weight. In fact, for temperatures above about 2300 R, the unaugmented engine provides better performance than the afterburning configuration even at the Mach number of 3.0. (Curves represent nonafterburning engine. Engine with afterburning is represented by points only, because turbine inlet temperature is held constant.)

development of aircooled blades has been carried out using chord lengths comparable to those necessary in the small gas turbine engine to prevent serious performance decay due to Reynolds number effects.

Apart from the actual cooled blades, the small turbojet engine is ideally suited to the incorporation of turbine cooling. The simple uncluttered design resulting with the advanced aerodynamic components allows efficient ducting of the required air to the turbine. The use of a highly loaded, single-stage turbine is obviously favorable in that only a single stator stage and a single rotor stage need to be cooled.

There are, of course, many other problems which, although not peculiar to the small engine, are perhaps more challenging than in the large engine. One of these is the combustion problem. With current combustion reference velocities it is possible to design engines in the pressure ratio range under discussion with combustion chambers and afterburners of essentially the same frontal area as the compressor and turbine. The difficulty lies in scaling down the combustion chamber length in proportion to the other engine dimensions.

At the present time, it appears that consideration of gas residence time required for satisfactory combustion dictates about as long a combustion chamber in a small engine as in a large one. Certainly the combustion chamber length cannot be scaled down in the same proportion as other dimensions. Even here there are mitigating factors. Increased length in the combustion chamber and afterburner is not too adverse from the weight standpoint because these are "low density" regions in the engine.

Also, with a proportionately longer distance for mixing in comparison with the burner passage height, a lower pressure drop is required in the small combustion chamber for the same degree of mixing, with a resultant slight increase in engine performance.

Another general problem area in the design of small engines is the maintenance of clearances and tolerances. Here, the principal weapons for the designer of small scale engines are design ingenuity and the maximum exploitation of manufacturing and fabrication technology. As an example, in both the compressor and turbine it is necessary to decrease the tip clearances as the blade height decreases. In the small engine this becomes a critical problem, but not one that is insoluble. By placing the bearings and supporting structure in the critical areas, and permitting the maximum flexural displacements to occur in noncritical areas it is possible to maintain tip clearances throughout the engine within acceptable bounds without substantial weight penalties.

To look somewhat farther ahead, it appears possible to design a small engine much more advanced than the one considered here. The advanced engine would be based on components which are currently in the research and development stage. This engine would provide even better high flight Mach number performance characteristics, with a thrust-to-weight ratio in excess of 15 to 1. It would utilize supersonic compressor elements and a cooled turbine. These components would be combined to exploit the optimum ranges of both compressor pressure ratio and turbine inlet temperatures for the high flight Mach number applications envisioned.

(Paper, "Potential Advancements in the Field of Small Aircraft Engines," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

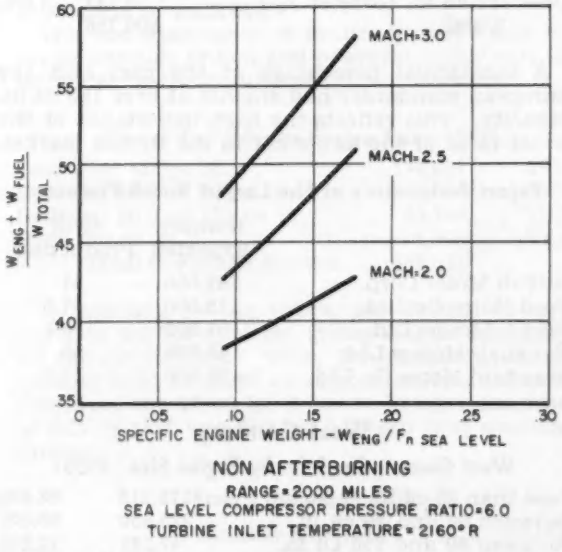


Fig. 6—For 2000-mile range, calculations show the ratio of total propulsion system weight to total vehicle weight increases sharply as specific engine weight (ratio of engine weight to thrust) increases. That is, payload goes down as specific engine weight goes up. If the "3/2 law" holds, then, payload goes down as engine size goes up.

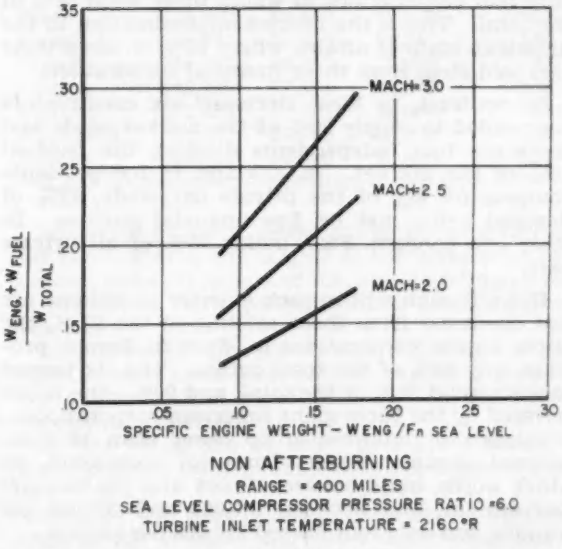


Fig. 7—For 400-mile range, as for 2000-mile range, the ratio of total propulsion system weight to total vehicle weight increases as the engine's thrust specific weight increases. These indications favor use of many small engines rather than a few big ones for a given propulsion task in the Mach 2-3 range, at altitudes of 50,000-70,000 ft.

FACTS ABOUT •Car Designs •Car Manufacturing •Volume of Production IN WESTERN EUROPE

Based on paper by **Laurence Pomeroy,** "The Motor," London.

THE American car is 25% longer, 50% heavier, and more than twice as powerful as the European type . . . and costs the home buyer half as much in terms of man-hours of the buyers' work.

One major difference between the American and Western European scene is that in the latter area political and trade barriers break production into a comparatively large number of units.

In France the automobile trade is divided between only four constructors, of whom three build 84% of the total. This is the nearest approximation to the American state of affairs, where 95% of the private cars sold stem from three financial corporations.

By contrast, in West Germany six constructors are needed to supply 90% of the market needs and there are four independents dividing the residual 10% of the market. In England 13 independents compete for 8% of the private car trade, 92% of demand being met by five financial entities. In Italy one concern, Fiat, builds 95% of all private cars.

But although within each country conditions are not dissimilar from those existing in the U. S., the three largest corporations in Western Europe produce only 36% of the total output. The six largest makers build 58% of the total, and 90%—the range covered by the three giant American corporations—requires the resources of no fewer than 16 commercial groups. Seven European companies, in other words, build between 50,000 and 100,000 cars per annum, four between 100,000 and 200,000 per annum, and only four exceed 200,000 per annum.

But many major influences and factors combine to bring about major differences in both design and volume between American and Western European cars. A summary analysis of production volume and the designs now being produced in Western Europe point up these differences.

Great Britain

British Car Sales by Engine Size (1955) (including imports)

Less than 60 cu in. (35 hp)	149,724	29.4%
Between 60 and 90 cu in. (35–50 hp)	203,912	40.5%
Between 90 and 150 cu in. (50–80 hp)	114,387	22.6%
Over 150 cu in. (over 80 hp)	38,733	7.5%
Total	506,756	

A substantial percentage of the cars sold (by European standards) had engines of over 150 cu in. capacity. This reflects the high importance of the social value of the larger car in the British market.

Export Performance of Five Largest British Producers

	Number Exported	% of Production
British Motor Corp.	147,000	41
Ford Motor Co. Ltd.	115,000	47.6
Rootes Motors Ltd.	51,000	53.4
Vauxhall Motors Ltd.	44,000	58
Standard Motor Co. Ltd.	31,000	31.6

West Germany

West German Car Sales by Engine Size (1955)

Less than 60 cu in. capacity	118,213	28.3%
Between 60 and 90 cu in.	225,550	60.0%
Between 90 and 150 cu in.	47,111	11.2%
Over 150 cu in.	2,458	0.5%

This gives a net total for cars registered on the home market in 1955 of 423,332.

The gross output of the West German automobile industry in 1955 was 762,205 vehicles, divided in respect of size as follows:

West German Output by Engine Size (1955)

Less than 60 cu in.	133,351	17.5%
Between 60 and 90 cu in.	529,384	69.4%
Between 90 and 150 cu in.	95,073	12.5%
Over 150 cu in.	4,397	0.6%

The West German industry divides into seven small and seven large concerns. The seven small firms produced 14,696 private cars between them, of which 10,916 were the 18 cu in. Goggomobils built by Glas Dingolfing. Most prominent in respect to reputation is Porsche, which made 2,952 sports cars during the year, of which the astonishing proportion of 80% were exported.

The German industry was second only to Great Britain as an exporter of private cars in 1955; went ahead of Great Britain in 1956. In 1955, the total number of cars exported represented 45% of the total made.

West German Cars Exported in 1955

	Number Exported	% of Output
VW	147,319	53
Opel	77,291	55
Mercedes-Benz	26,743	44
Ford	24,172	44
Borgward	11,098	48.5
Auto Union	10,847	33

France

With an area of 215,000 square miles, France—with 20,300,000 population—is substantially the largest country in Western Europe. One Frenchman in 17 owns a motor vehicle, giving a total car population of 2,522,000.

The fast open roads of France do not result in a preponderance of fast and powerful motor cars, the deliveries to the home market in 1955 being:

French Car Sales by Engine Size (1955)

Less than 60 cu in.	178,651	43.5%
Between 60 and 90 cu in.	149,012	35.5%
Between 90 and 150 cu in.	90,348	21%
Over 150 cu in.	1,000	Trace
Total to French Market	419,011	

In addition to the above, the French industry exported 141,750 vehicles, giving a total for 1955 of 561,465 constructed. With the exception of 1365 vehicles built by three small constructors (of which 1224 were the 18 cu in. 2-stroke Velam) the whole of this market was divided between four manufacturers:

French Exports in 1955

	Number Exported	% of Production
Renault	55,316	31.5
Simca	39,697	28
Peugeot	23,150	25
Citroen	18,601	15

Italy

Of the total cars registered in Italy, 150,870 (98%) bore the name Fiat.

Italian Car Sales by Engine Size (1955)

Less than 60 cu in. (35 hp)	87,340	53.94%
Between 60 and 90 cu in. (35–50 hp)	67,868	41.92%
Between 90 and 150 cu in. (50–80 hp)	6,645	4.14%
Over 150 cu in. (over 80 hp)	100	Trace
Total	161,953	

Italian Car Exports

	Number Exported	% of Production
Fiat	67,430	30.9
Alfa Romeo	1,196	20.2
Lancia	596	9.1

Owing to the immense Fiat preponderance, this gives a national export percentage of 30.06% for 69,397 cars.

Western Europe in General

There are 10 companies in Europe capable of producing 100,000 cars per annum or more, and the principal figures relating to them can be tabulated thus:

1955 Statistics of 10 Largest Western European Automobile Makers

	Output	Exports	Employees	Value Capital × 1,000,000
B.M.C.	350,770	147,000	55.045	183
VW	290,832	147,319	31,570	110[b]
Ford (G.B.)	241,502	115,000	25,910	235
Fiat	218,300	67,430	72,000[a]	280
Renault	176,260	55,316	52,241	140
Simca	149,023	39,697	15,900	32[b]
Opel	142,795	77,291	31,570	200[b]
Citroen	122,422	18,601	30,000	53[b]
Standard	98,647	31,000	10,000	32
Rootes	96,000	51,000	20,000	31

[a] 42,252 on vehicles. [b] nominal.

Measured either in terms of employment or capital value, Fiat is the largest of the companies concerned, but a large part of its capital and manpower is concerned with products other than wheeled vehicles.

In numbers of private cars built during the year B.M.C. had a clear lead, and for practical purposes B.M.C. shares first place with VW as the world's biggest car exporters.

Of the 10 largest builders, four are situated in Great Britain, three in France, two in Germany, and one in Italy.

(Paper, "The Size, Structure, and Export Performance of the Western European Automobile Industry," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

nuclear news notes

reported by

SAE NUCLEAR ENERGY ADVISORY COMMITTEE

Nuclear Papers Available

THE 1957 Nuclear Engineering and Science Conference last March, of which SAE was one of more than a score of sponsoring societies, was productive of several hundred technical papers. The SAE Nuclear Energy Advisory Committee reviewed the list of available papers and selected the following 26 as those which may be of interest to SAE members. They may be ordered, by number, from the ASME Order Department, 29 West 39th Street, New York 18, N. Y.

57—NESC-113
"Heat Transfer Considerations in the Use of Organic Reactor Coolants," by T. T. Shimazaki and W. F. Anderson

57—NESC-73
"Educational Uses of the Small 5-Watt Laboratory Reactor," by John W. Flora

57—NESC-49
"Methods for the Production of Thorium Metal," by O. C. Dean

57—NESC-52
"The Economic Background for the Competitive Development of Nuclear Power," by Harlan W. Nelson and W. R. Keagy, Jr.

57—NESC-101
"Economics of Ceramic Fuel Elements for Nuclear Reactors," by J. R. Johnson

57—NESC-118
"Nuclear Waste Economics—State of the Art," by Eli I. Goodman

57—NESC-30
"Nusselt Values for Estimating Turbulent Liquid Metal Heat Transfer in Non-Circular Ducts," by James P. Hartnett and Thomas F. Irvine, Jr.

57—NESC-64
"Natural Convection inside a Horizontal Cylinder," by William R. Martini and Stuart W. Churchill

57—NESC-61
"Evolution of Neutron Sensing Elements-Scientific Laboratory to Industrial Application," by Leslie E. Johnson

57—NESC-84
"Ultrasonic Flowmeter Monitors Reactor Heat Exchange Circulation," by M. Koblenz, R. Spiegel, S. Kass, and H. Sterling

57—NESC-11
"Development of Safety Standards for Nuclear Propulsion of Merchant Ships," by C. P. Murphy and A. R. Gatewood

57—NESC-5
"Uranium-Columbium Alloy Diagram," by B. A. Rogers, D. F. Atkins, E. J. Manthos, and M. E. Kirkpatrick

57—NESC-6
"Internal Friction and Shear Modulus of Thorium at High Temperatures," by C. E. Dixon and H. Hori

57—NESC-9
"Effect of Cold Work on the Mechanical Properties of Zircaloy-2," by F. Forscher

57—NESC-13
"The Effect of Irradiation on the Tensile Properties of Uranium," by R. E. Hueschen, R. S. Kemper and W. S. Kelly

57—NESC-15
"Metallographic Studies of Neutron Irradiated Non-Fissionable Metals," by Charles A. Bruch, William E. McHugh, and Louise J. Doig

57—NESC-33
"On the Quality Requirements for Steel Valves for Nuclear Power Plants," by J. J. Kanter

57—NESC-98
"Pumps for Nuclear Power Plants," by Arthur F. Erwin

57—NESC-103
"Pressure Piping as Related to Nuclear Applications," by D. B. Rossheim, J. J. Murphy, C. R. Soderberg, Jr., and H. S. Blumberg

57—NESC-108
"Applicability of Clad Steels to Heavy Wall Piping," by J. H. Proctor

57—NESC-82
"Power Reactor Containment Vessels," by Arthur J. Raymo

57—NESC-116
"Design Considerations for an Atomic Power Reactor Containment Structure," by William C. Siler and Leonard P. Zick

57—NESC-117
"Basic Concepts in the Application of Ionizing Radiations to Foods for Preservation," by B. H. Morgan, G. E. Danald, G. E. Tripp, and D. F. Farkas

57—NESC-79
"Nuclear Powered Gas Turbines for Light Weight Power Plants," by Frederick G. Hammitt and Harold A. Ohlgren

57—NESC-111
"Stress-Corrosion Cracking Problems in the Homogeneous Reactor Test," by Edward G. Bohlman and George Adamson

57—NESC-17
"The Application of Radioisotopes to the Measurement of Soil Moisture Content and Density," by Paul F. Carlton

Objectives and Problems Of Turbocharged Diesel

Based on paper by

MERRILL C. HORINE
Mack Trucks, Inc.

TURBOCHARGED automotive diesels make possible greater horsepower and torque output without increase in size and with only trifling additional weight or complication. Equivalent economy has been preserved, the noise level has not been raised, and maintenance cost has not been increased. The same degree of reliability has been sustained.

The demand for better performance, lighter weight, and greater compactness has been met by gasoline-engine designers by higher rotative speeds, made possible without exceeding safe piston speeds by the use of lower stroke-bore ratio and/or an increase in number of cylinders beyond the conventional six. Compression ratios and volumetric efficiency have been increased.

The diesel-engine designer is faced with a different problem. Rotative speed is limited by the peculiarities of fuel injection, there is little to gain from any increase in compression ratio, and thermal efficiency is already substantially higher than that of gasoline engines.

Specific output of the conservative naturally aspirated 4-stroke diesel is well below that obtained from gasoline powerplants of equivalent quality. Brake mean effective pressure is limited to about 108 psi, while approximately 1 hp is developed for every 12 lb of weight and about 0.25 hp per cu in. of piston displacement.

Higher consumption of power in internal friction, due to higher pressures, in compressing the charge farther and in the operation of the injection system, is responsible for the lower specific output of the diesel. Happily, owing to the fundamental principle of compression ignition, the diesel is not sensitive to air-fuel ratio, as the gasoline engine is, and therefore thrives on excess air and exhibits admirable economy at part load for all speeds. These make it particularly well adapted to supercharging.

Supercharging increases volumetric efficiency up to, or even beyond, 100%, resulting in a considerable boost in power without any increase in piston displacement. Mechanically driven centrifugal or Roots-type superchargers can be used, but a considerable portion of the extra power generated is consumed in driving the blower. Additional disadvantages are the noise and maintenance problems of the drive mechanism and the fact that the extra air forced into the cylinders is proportional to speed rather than load.

Since the speed of a turbocharger is

dependent upon the volume of exhaust passing through it, the amount of supercharge is always in proportion to the load on the engine. With only one moving part, no close clearances within its casings and no mechanical drive, the unit is long-lived and trouble-free. An unanticipated benefit of turbocharging is the effective noise suppression action of the turbine, permitting operation without a muffler within the prescribed limits of 125 sones.

The principal disadvantage of turbocharged engines is a lag in acceleration due to the fact that the volume of exhaust gases must increase before the impeller can supply additional air. Starting can also be a problem if compression ratio is reduced to compensate for additional boost. Pressures on main bearings are increased, but the rate of pressure rise is lower. Valve timing may require modification to ensure effective scavenging, and manifolds usually require extensive changes.

Compared to the naturally aspirated engines mentioned earlier, bmep is increased to 140 psi, hp per cu in. stepped up to 0.37 and specific weight reduced to 9 lb per hp.

(Paper, "Objectives and Problems of the Turbocharged Diesel" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Kansas Turnpike Has Narrow Median Strip

Based on talk by

L. W. NEWCOMER

Chief Engineer, Kansas Turnpike Authority

(As reported by Kenneth Rix, SAE Wichita Section Field Editor)

THE new 236-mile Kansas Turnpike has a 20-foot median strip between the lanes, and a ten foot paved, asphaltic shoulder on the outside and a four foot paved shoulder on the inside.

Many turnpikes have a wide median strip. State standards for the new Federal program are 53 ft minimum, but it was found to take only 0.3 sec to go the additional distance if a car cuts across the median at 60 mph. The extra footage seemed relatively unimportant as the wider median strip would have cost millions of dollars more. The biggest disadvantage of the narrower median strip is the reflection of lights from oncoming cars, which was not found to be objectionable.

The road has a maximum of 3% grade and is designed for 38,000 lb per axle, which is double the statutory limit used by the Kansas State Highway Department. The curves are kept at a maximum of 3 deg, which gives almost a 2000-ft radius. There are curves to miss oil wells, high hills, deep cuts, buildings, and land whose owners seemed to think might contain uranium. A curved road is also less monotonous than a straight road.

There are 55 miles of concrete and 181 miles of flexible type paving. It was strictly an economic point of view which determined this construction. Both types of construction were designed for the same load resistance and cost about the same. The concrete design is a 4-in. base covered with a 1-in. sand evener and a 10-in. reinforced slab. The asphaltic concrete is a 10-in. subbase, 8-in. base (all 100% compaction), and a 4-in. hot mix on top of that.

Ultimately, luminous paint may be put along the edge of the highway. Painting now would leave a ragged edge as the loose white cover material has not yet become set. While it is new, the white cover material makes a good line.

The grade slopes were seeded and covered with straw. This in turn was sprayed with a heavy non-permeating oil (cut back asphalt). The grass grows through the mulching.

There is a speed limit of 80 mph and a minimum speed of 40 mph.

Direct-Cooled Motors Built for Earthmovers

Based on paper by **DONALD R. BUERSCHINGER** LeTourneau-Westinghouse Co.

SPECIAL electric motors with direct cooling under all operating conditions have been designed for earthmoving equipment. A typical motor with rotor partially removed is shown in Fig. 1.

The motor is a 3-phase squirrel-cage induction type, rated for intermittent duty and designed as a high-starting-torque motor. Its open-end design permits direct cooling not only when the motor is running but also when the machine is in motion.

The motor stators are wound for 4-, 6- or 8-poles, depending on the application speed required. The rotor also has many design features. The squirrel cage is extended on one end while a special stainless-steel end bell is used to complete the cage at a considerable distance from the lamination stack. The reasons for this are as follows:

1. The largest portion of rotor resistance is designed into the steel end bell. The rotor heat is then concentrated in the resistance of the end bell where it is easily dissipated.

2. Heat concentration in the end bell during starting conditions will increase its resistance and thus its torque. Cooling of the end bell after the motor is up to speed will reduce the rotor resistance and permit more efficient operation under load.

3. The rotor bars provide a fan action for added cooling.

The motor was designed for the rugged duty met in earthmoving work. While in the cut loading, the motor can be reversed many times a minute and then lift a heaped bowl as required.

(Paper "Electrics In Earthmoving Equipment" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

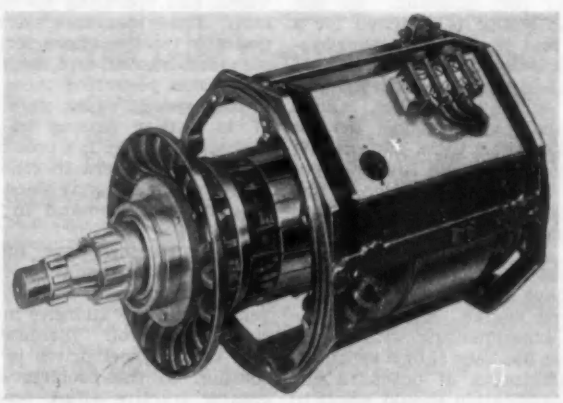


Fig. 1—Direct-cooled motor for earthmoving equipment shown with the rotor partially removed. Fan action of rotor bars aid in cooling.

Fuel-Injection Systems Evaluated

Based on paper by

C. H. NYSTROM
American Bosch Arma Corp.

THERE are two basic types of fuel-injection systems available for gasoline engines—timed and constant-flow.

Among the timed-injection types are the American Bosch and the Borg-Warner. They are alike in using a speed-density type of control. Then there is the Bendix Electrojector system which uses an electronic type of control. Finally, there is the Lucas system which employs a shuttle-type valve instead of a reciprocating plunger, but uses a speed-density type of control. The Holley Carburetor Co. has a license for this system and will carry on developments in this country.

General Motors is using a ram-jet constant-flow system for the Chevrolet and Pontiac. During development of its time-metered system, American Bosch built and tested a constant-flow type of system similar to the present GM system, but decided that the time-metered injection system offered the greatest advantages for both existing and future engines. Presumably many companies are working on this constant-flow system today.

A great deal of work remains to be done to get the maximum benefits from gasoline injection, such as redesign of manifolds to incorporate ram effect, as well as the possible use of direct injection into the combustion chamber. This would give better starting and acceleration. Better combustion-chamber design might improve internal cooling, thus permitting higher compression and better volumetric efficiency.

Mercedes-Benz has experimented long with timed injection direct to the combustion chamber. Their engine is designed for fuel injection. In this country, the engine is designed for a carburetor and the fuel-injection system is applied as an afterthought.

The timed-injection system, whether it be port or direct injection, allows the oil companies to consider the use of fuels other than those current. It might be possible to use higher vapor pressure fuels and eventually a fuel with a wider boiling range. Various oil companies are studying the prospects.

The timed-injection system would appear to have a great potential in the 2-stroke-cycle engine. European companies are experimenting with it and some interest has been shown by American manufacturers of outboard engines. Its application should result in increased power for the same engine weight.

Supercharging promises to be much simpler to apply to injection than to carburetion. Finally, looking far into the future, there may be some development along the line of controlled combustion, that is, a multifuel type of engine such as developed by the Texas Co. Various universities, oil companies, and engine companies are working on this idea and if someone should be successful, it would greatly increase the use of fuel injection.

(Paper "Automotive Gasoline Injection" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

500-Hp Tractor Foreseen for Near Future

Based on talk by

M. BENNETT
International Harvester Co.
(Presented before SAE Chicago Section)

THE trend toward increased power and simplicity of operation is by no means slackening for either crawler or wheel tractors. Rather, it is quite evident that the manufacturers are engaged in a horsepower race with the practical limit not yet in sight. Twenty years ago, there were few predictions that tractors of 200 hp would ever be as common as they are today. Several years from now, it is entirely possible that 500-hp tractors will be just as common.

New types of final drives with infinitely variable steering ratios may well be one of the design developments that will be incorporated in the tractor of tomorrow.

If the crawler tractor is to find a wider acceptance in the future, some basic changes must be made in its suspension system. During World War II, track-type equipment was developed which had operating speeds up to 60 mph. These machines had most of the desirable traction characteristics of the standard crawler, and their bogie-type suspension permitted them to operate at high speeds, which were undreamed of in earlier designs of track-type equipment. Here is a possible basis for future development in crawler tractor suspension which may place the crawler even more in demand in tomorrow's market.

Wheel tractors have future design changes in store for them that will increase their tractive effort under adverse conditions and give more positive steering control. Increased application of all-wheel drives is a probable solution to the problem of securing greater tractive effort under adverse conditions; and steering changes are in propect that will give increased effectiveness and greater operating ease.

What is in store in the realm of operator environment? The trends are toward increased ease of control, operator comfort, and protection from noise, dust, and heat. It is conceivable that the operator of tomorrow's equipment will be comfortably ensconced in an air-conditioned cab with control tower visibility. He will use little muscular effort in controlling his giant powerplant because power systems will furnish the required controlling forces.

Fan Noises Can Be Cured

Based on paper by

K. A. BEIER
Schwitzer Corp.

BECAUSE of the trend to higher horsepower engines, cooling fans must either provide greater capacity or operate at higher speeds. This results in greater fan noise. However, this can be reduced by:

- Reducing obstructions, if possible.
- Shrouding.
- Using proper fan design.

While the disadvantages of an obstructed installation are widely recognized, the magnitude of the effect is not always appreciated. But the effects can be demonstrated by the following experiment: Two identical fans were tested; one free of obstructions, the other with obstructed airstream. Obstruction included the entrance of the core inside the plenum chamber to simulate the bar-type grille. Airflows were kept the same by changing the speed of the unobstructed fan. The speed of the latter was 3210 rpm as opposed to 3600 rpm for the unobstructed fan. The noise level for obstructed fan was 97 db; for the unobstructed fan 93.5 db. The power output was reduced 20%.

Shrouding can be very effective. Using the same fan as in the obstruction test, identical performance was obtained when running at 3600 rpm without a shroud and running at 2260 rpm with a shroud. The shroud was

Table 1—Results of Test to Show Effects of Various Fan Shapes on Performance (Constant airflow of 7400 cfm was maintained for each fan, adjustment being made by changing the speed)

Fan	Speed rpm	Noise Level db
Reference fan	3600	91
High angle—narrow blade	3574	95
Low angle—wide blade	4000	86.5
Bent tip	3675	90
Tapered-screw blade	3850	94.5

about 4 in. deep with conical conversion section. The clearance between OD of fan and shroud was about 1 in. Noise level dropped from 94.5 to 87.5 db. Fan power was reduced 79%.

Shrouds may increase the noise level due to vibration. To demonstrate this, a production truck shroud was tested with the standard fan. Bracing and stiffening the shroud to prevent vibration reduced the noise level from 84.5 to 82 db. Fan speed was 2000 rpm, which seemed to be the resonant point of the shroud.

Fans can be tailored for particular installations. Several designs are listed in Table 1. If the air path is not obstructed highly behind the fan, low angle and wide blades will promote axial discharge of the air. With high obstruction axially behind the fan, the fan should deliver the air in a radial direction. Radial flow discharge is particularly important on a V-8 installation.

A fan can take several special forms to promote radial flow. A narrow-blade, high-angle fan will have a high radial discharge component in most installations, but it is not considered a desirable type because of high power consumption. Deep blade cambers also promote radial flow, but are not too efficient. A better method is to use the "bent-tip' pioneered by Schwitzer. An infinite number of forms and shapes can be applied to the tip, but a constant radius of curvature of the tip section seems most effective for nonshrouded applications. For shrouded applications a tip section generated on a conical surface seems best. Among other forms are variable angle blades, where the chordal angle increases from tip to heel of blade, and tapered blades where the blade is wider at the heel than at the tip.

With reference to Table 1, note that, while the speed of the high-angle, narrow-blade is lowest, the noise level is maximum; that, although the speed of the low-angle, wide-blade is maximum, the noise level is the lowest. To obtain specific airflow requirements with the latter design, speeds in many cases will be too high, but whenever possible this design should be used.

The "bent-tip" design proved to be the next best. There was no advantage whatever in the use of the tapered-screw type of blade.

Fan blade spacing has been studied to obtain different tonal qualities of the fan noise. By varying the number of blades and blade spacings, about any pitch of noise can be obtained to blend with other installation noises. As a general rule, the multiblade design fans tend to produce a lower intensity of noise, but the pitch will be higher.

(Paper "Fan Noises and Some of Their Cures" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Synthetics Gain Ever Greater Automotive Use

Based on paper by

H. A. HOPPENS

Barrett Division, Allied Chemical & Dye Corp.

MANY new synthetic routes are continually being opened to "chemically create" new things. So, any permanent reference to products and performance of "plastic" materials cannot be soundly made.

However, each of the existing 10 or more basic types of resin materials (each available in two to six different forms) has brought some special benefit or service. The designer makes these benefits available to the car owner by intelligent application of particular materials to particular elements of his design.

The following table details many of the sound applications currently being made:

Type of Material	Form	Example of Application
1. Acrylics	Molding compound	Tail light assemblies
	Lacquer	New finishes
2. Cellulose (acetate and butyrate)	Molding compound	Steering wheel; buttons
3. Copolymers	Rigid sheet	Headlining; side panels
4. Melamine	Molding compound	Knobs
	Enamel	New finishes
5. Nylon	Molding compound	Door striker; dome lens
	Fabric	Upholstery
6. Phenolics	Molding compound	Distributor caps; rotors
	Liquid and powdered	Brake linings; insulation binder
7. Polyester	Premix	Heater housings
	Laminating resin	Body parts
	Foam (urethane)	Padding
	Film ("Mylar")	Upholstery welting
	Molding compound ("alkyd")	Coil tops
	Paint (oil modified alkyd)	Finishes
8. Polyethylene	Molding compound	Fasteners; plugs
	Film	Door water shield
9. Saran	Extrusion	Seam welt filler
10. Urea	Molding compound	Knobs
	Enamel	Finishes
11. Vinyl	Molding compound	Grommets; knobs
	Extrusion	Window weatherstrips
	Coated fabric	Trim material
	Clear sheet	Rear window glazing
	Safety glass interlayer (polyvinyl butyral)	Safety glass
	Foam (vinyl chloride)	Instrument panel padding

(Paper, "Types and Forms of Chemically Created Materials for Automotive Engineering" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

"Crosscut" Tire Trend Gives Better Traction

Based on talk by

WILLIAM B. FLORA B. F. Goodrich Co.

(Presented before SAE Canadian Section)

TREAD design of the "Lifesaver" premium tire is based on the well-known traction advantages of slicing or cutting across the tread. The closer the cross-cuts, the better the traction. Normally, though, as the distance between the cross-cuts becomes less, the noise level increases . . . from a low hum . . . to a high pitched, objectionable sing.

With a 1/16-in. spacing, it has been found that the pitch of the sound is above the audible range of the human ear. The noise is still there but it is pitched so high you can't hear it.

The main feature of this tread is that it provides thousands of individual, flexible rubber blocks that grip the road, and provide amazing traction qualities.

Because the crosscuts go completely across the tread, when you lock the wheels on a wet road, the tread works like a windshield wiper . . . wiping the road dry—for faster stops . . . so dry you can actually light a match on it!

The flexible blocks also give the tread a walking or caterpillar action which reduces scuffing and increases mileage. Also, as each block is independent and flexible, unusual steering ease, especially when parking, has been noted.

Many Factors Affect Satellite Orbit Accuracy

Based on talk by

HOMER STEWART

California Institute of Technology

(As reported by W. E. Achor, SAE Southern California Section Field Editor)

IN launching a satellite there is always the possibility of error in establishing the proper angle of trajectory, attaining the required velocity, and other factors. If such a condition occurred during flight, the satellite could approach the earth close enough at a point in its orbit that the drag of the atmosphere would cause it to fall to earth.

If you are trying to make a trajectory with a reasonably high degree of eccentricity and you don't care to hold it too close to that, then your guidance problems on establishing it in an orbit are not too critical. Also, the accuracy of holding the angle of launching and the velocity are not too critical.

This is the approach being used on Vanguard Satellite flight calculations.

But if a circular orbit is desired, then the above mentioned conditions become much more critical.

Cabin Environment In an Inhabited Satellite

Based on talk by

VINCENT BLOCKLEY

North American Aviation, Inc.

(As reported by W. E. Achor, SAE Southern California Section Field Editor)

MAN is designed for living in a very narrow band of temperature and condition. However, he has great capacity for adaptation and counteraction to conditions outside this band.

In vehicles that would operate beyond the atmosphere for only short periods of time, protective equipment plus the tolerance capacity of man would be sufficient to withstand the thermal conditions.

Now, as we get into a time duration of one to fourteen days, these engineering aids are not enough. We could accept temperatures of 90–100 F for this period of flight if means were provided for relieving the heat accumulations periodically.

The environment for respiration purposes have very severe limitations.

On short flights, bottled oxygen would be sufficient. Also, the use of pressurized suits would reduce the space that required ventilation.

On longer flights, neither of these is practical.

Approximately 20 lb per hr of oxygen is required per man, so storage is a problem. Possibly a biological system, such as the use of the properties of chlorophyll in the form of algae, could be developed to convert the expelled carbon dioxide back into oxygen.

The human body also produces water from perspiration and quantities of odors which must be removed by air conditioning. Here again the weight and space requirements of such equipment pose many problems.

Because of the weightlessness condition present in space flight, some action must be taken to remove the exhaled gases adequately from the breathing area and provide fresh mixtures.

Earth is Composed Of Three Sections

Based on talk by

BENO GUTENBERG

California Institute of Technology

(As reported by W. E. Achor, SAE Southern California Section Field Editor)

THE earth is composed of an inner core, which is either liquid or solid; the outer core which is liquid, the mantle, and finally the very thin crust.

The density of the earth varies from the crust to the core. The various densities are not well known, but some indication can be gained by observing the effect of the earth on the motion of the moon. It is hoped that the orbit traveled by the satellite will also aid this study.

The earth's crust averages 20 miles deep. There is considerable disagreement as to the density of this crust and also the effects it may have on gravitational force.

Surveys made of the earth's surface indicate significant gravity anomalies particularly when comparing ocean covered areas with mountain covered areas.

It is difficult to guess what effect, if any, these gravity anomalies will have on the orbit of travel of the satellite.

Cosmic Radiation Dangers at High Altitude

Based on talk by

HERMANN J. SCHAEFER

Naval School of Aviation Medicine

(As reported by W. E. Achor, SAE Southern California Section Field Editor)

THE question whether cosmic radiation can develop any harmful effects on matter is not very old.

Only eight years ago, in 1948, did we learn that primary cosmic radiation has a component which no one anticipated up to that time; that is, heavy components.

The discovery of heavy nuclei in cosmic radiation is actually the starting point of our worries.

The measure of biological dosage is in Roentgen units and an international definition of a permissible dose is 50 milliroentgens per day.

At sea level 0.1 milliroentgens are produced per day. At a higher level outside our atmosphere about 10 to 15 milliroentgens per day are produced.

It would be premature to conclude that there is no danger involved.

It appears that the heavy components of cosmic radiation cause a concentrated zone of ionization along the paths of projectory. Other components of radiation cause ionization over a considerably wider area.

Thus, the heavy nuclei cause a high concentrated dosage, which can be dangerous. For a study of its effect, a black-haired mouse was flown at a high altitude for 6 hr while its mate was kept at sea level. Some weeks after the flight the former mouse developed numerous white hairs over its body while its mate showed no changes.

From the results of this study it probably can be assumed that the heavy nuclei damaged some of the hair follicles in the mouse, thus causing the hair to lose its color.

Some Mechanical Factors Involved in Space Travel

Based on talk by

JOHN R. POPPEN

Douglas Aircraft Co.

(As reported by W. E. Achor, SAE Southern California Section Field Editor)

THE mechanical factors which might have physiological import are essentially restricted to the parts of the space trip that are within the air envelope.

These refer particularly to the impact, the dynamic effect of air under high speed, and its related effects.

Weightlessness is impossible to build into a laboratory situation. One must overcome gravitational force, initial force, and external forces, and this can be done only in an orbiting vehicle.

Weightlessness has been experienced to some degree in an airplane following a parabolic glide path, but the problem in this situation is that the period is too short in duration. Also, the transition periods are considerable.

In contemplating the possible effects of a weightlessness condition, the following are due consideration:

1. Locomotion: A minimum of physical effort is required and considerable training and experience will be necessary to meet the situation.

2. Eating: Since we won't be able to pour liquids, some means of injecting them into our mouths will be required. Solid foods don't appear to pose a problem. Swallowing may be a problem

but probably the peristaltic action will take care of it.

3. Body functions: There is no evidence at this time that there would be any impairment of the functions. Of course there would have to be some means of circulating the air to remove the exhaled gases from the breathing area and bring in fresh mixtures.

The gravitational forces developed by the high velocities will be in excess of those experienced in flight of airplanes. We would undoubtedly have to be in a supine position when leaving and re-entering the air envelope to be able to withstand these forces.

The biggest problem is during the re-entry period. The vehicle will enter at a steep angle to the earth's surface, but in order to land it must be changed to horizontal flight and the gravitational forces during this turning period appear to be excessive.

Of course this may be solved by producing a decelerating thrust of some sort to reduce the speed of the vehicle.

Orbits in the Earth's Actual Gravitational Field

Based on talk by

SAMUEL HERRICK

University of California at Los Angeles

(As reported by W. E. Achor, SAE Southern California Section Field Editor)

IF, after the initial trajectory, a satellite is launched horizontally, it would travel a circular orbit if its speed was 4.9 miles per sec. If its speed was less, then it would fall back to earth in an inner ellipse. If its speed was increased to 6.9 miles per sec it would follow a parabolic path and never return to the earth. A speed of 8.5 miles per sec would carry the satellite off on a hyperbolic orbit.

It has been agreed that the speed of the satellite should be somewhat above 4.9 miles per sec, so that it will follow an elliptical orbit. This will allow a small error in the angle of projection and help insure that the satellite will not return to earth.

It is possible that the gravitational forces of other planets may cause the satellite to vary somewhat in its elliptical orbit.

Of course the largest perturbation on the satellite will be caused by the bulge of the earth at the equator.

Sun-Earth Radiation Will Warm Earth Travelers

Based on talk by

HEINZ HABER

Chief Science Consultant, Walt Disney Studios

(As reported by W. E. Achor, SAE Southern California Section Field Editor)

SOLAR and terrestrial radiation will be the two factors determining the temperature of a space vehicle.

There are two common fallacies concerning outer space. The first is that space has temperature. This is impossible by definition. The second is that any body in space would be frozen in short order. This is wrong as evidenced by the temperature of the earth, which is a body in space.

We have been space travelers since the beginning of our species, and the earth has maintained an average temperature of 15 C. Of course the earth's atmosphere helps to smooth out the extremes in temperature.

The sun is the primary heat source for a body in space, while the earth contributes some also. Since the laws of physics that determine radiation apparently are quite accurate, we have a powerful theoretical tool.

As a body absorbs radiation, its temperature rises. But as the temperature rises the body will lose an increasing amount by radiation until an equilibrium temperature is reached when input equals output.

Metals can be heated to high temperatures by radiation because they themselves are poor radiators in the infra-red section of the spectrum. Coating a metal satellite with magnesium oxide or something white could improve this condition somewhat.

To simulate a space condition in a laboratory for the study of radiation effects, we need to do the following:

1. Provide a tank that can be pumped to a very high vacuum so as to reduce heat conduction through the air.

2. Hang the body to be studied inside the tank using a thin glass thread to also reduce heat conduction.

3. To simulate the heat sink effect of free space probably a series of metal baffles covered with lamp black and cooled by liquid air would be sufficient.

4. To simulate solar radiation is difficult. Our closest approach to the 6000 C temperature of the sun is the 4000 C temperature produced by a carbon arc. The sun itself might be utilized if a reflecting and concentrating setup could be properly designed.

5. To simulate earth's radiation would also be difficult, but it probably could be done.

All this equipment and the setups would be costly, but the experimentation must be done if we are going to be space travelers.

Air Density Controls For Fuel-Injection Pumps

Based on paper by

JOHN HUMBER

American Bosch Arma Corp.

(As reported by W. O. Koehler, SAE Metropolitan Section)

THE fuel-injection pump and governor of a diesel engine is nominally a speed-sensitive metering device which delivers a specific fuel quantity to the engine commensurate with the existing speed and load on the engine. The fuel delivery characteristic of the pump is tailored to match the full-load torque requirements of the engine. This, in turn, is dependent on available excess air for efficient combustion with acceptable smoke at all speeds.

Density of air at a constant temperature decreases at the rate of 3% per 1000-ft altitude. Thus, the mass of air consumed by an engine operating at high altitude will decrease at approximately the same rate. If exhaust smoke is to be avoided, fuel delivery must be reduced at high altitudes to compensate for the decreased amount of air. An altitude-compensating device, consisting of an aneroid bellows linked to an adjustable full-load stop, accomplishes this action by moving the stop plate toward less fuel as altitude increases.

With turbocharged diesels, there is a tendency toward excessive smoke when the engine is suddenly accelerated from idle or part loads at lower speeds. Until the impeller accelerates to proper speed, too much fuel is delivered by the pump, resulting in a rich mixture. A compensator operated by manifold pressure is used to reduce maximum fuel delivery under such conditions. A diaphragm, sensitive to manifold pressure, is connected to an adjustable full-load stop. When manifold pressure drops, the stop is automatically moved to restrict the amount of fuel delivered.

A third type of compensating device reduces maximum fuel delivery with increase in altitude and also provides further fuel reduction at low manifold pressures to prevent smoking during rapid acceleration. It is similar to the manifold pressure compensator, but also contains an aneroid bellows for altitude compensation. (Paper, "Air Density Controls for Fuel-Injection Pumps," on which this abridgment is based, presented before SAE Metropolitan Section, is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York City 17. Price: 35¢ to members, 60¢ to nonmembers.)

Positive Filtration Gives High Efficiency

Excerpts from paper by

A. P. BELMONTE
Industrial Wire Cloth Products Corp.

POSITIVE filtration refers to the action of air, or oils, passing directly through the filter media. Dirty air or oil passes through the filter and leaves the dirt particles on the filter surface, emerging clean on the other side.

The advantages of the positive dry-type air filter over the oil-baffle type are varied:

1. The efficiency of the positive air filter runs 98% plus initially, increasing to 99–99.5% as the filter collects more and more dust particles.

This high degree of efficiency is held quite constant, never going below 98% even at the lower engine airflows experienced by fleet operators. The oil-bath type is only 90–94% efficient at the lower airflows and increases to 98% when using 200–250 cfm. This efficiency increase results from more air demand, greater velocities, and consequently more oil being pulled up to adhere to the filter pack, which in turn attracts the particles of dust to the oil-wetted hair or fibers. However, at extremely high airflows (in the order of 400–450 cfm) the efficiency again drops off to an unsatisfactory level. At low airflows as well as high airflows, the oil-bath cleaner sacrifices the main purpose of filtration by reducing the efficiency from 98% down to 90%, while the efficiency of the positive dry type has a differential of only 1–1½% no matter what the velocity or air demand—from 99.5% down to 98%.

2. The initial net pressure drop across the positive dry-type filter is ½ in. of H_2O at 200 cfm as compared to the oil-bath type, which runs 1–1½ in. of H_2O for the same airflow. This lower restriction in the dry filter allows more air, mixed with more fuel, and consequently results in better performance, provided the carburetor setting is made for such ideal lower restriction conditions.

3. Servicing the dry type is quite simple. You remove the filter, shake off the excess dirt particles by tapping gently, and reinstall the filter. This is done approximately every 5000 miles under normal highway driving conditions for the filters used on the Chrysler, and suggested to be done every 2000 miles for the Ford units. In the west where dustier areas are encountered, more frequent servicing is advised. As to the matter of filter replacement, it should only be necessary every 15,000 miles and again more often in dustier and more extreme conditions.

4. The life expectancy of the dry-type has been arbitrarily set at 15,000–20,000 miles or approximately one year for the average motorist for normal highway driving conditions. More frequent replacement is suggested for units used in dustier areas. Although this may appear as a disadvantage and that replacement costs might seem to occur too frequently, it is well to remember that the small cost of replacing the positive dry-type filter certainly is a fraction of the costs that would be involved for down time and engine repair bills if some other type of filter were used that did not remove harmful abrasives from the air before entering the engine.

(Paper, "Positive-Type Air Intake Filters," was presented before SAE Metropolitan Section.)

Air Motor Makes Bid For Actuating Systems

Based on paper by

W. W. WILLIAMS
Lear, Inc.

AIR motor powered high-temperature actuating systems offer a number of advantages over turbine powered systems. These are:

1. High torque to inertia ratio. Due to the higher inertia and very high angular velocities needed by a turbine, the gear air motor is much better adapted to modulating or quick-acting actuation applications.

2. Low operating rpm. Since the air motor is a pressure-relief device, it develops high torque at starting and performs similarly to a direct-current aircraft electric motor. A turbine yields lower starting torque and requires a high blade speed to jet speed ratio for reasonably efficient operation.

3. The air motor torque is proportional to the gage pressure available in the bleed air, and virtually unresponsive to temperature changes in this air. This yields a fairly constant performance output. A turbine is subject to large variations in performance if the temperature of the compressor bleed air changes appreciably, and turbine power is proportional to a power of the pressure ratio times the absolute temperature.

4. The air motor has low leakage whereas a turbine, a velocity-type machine, has high leakage even when not revolving.

5. Efficiency over a wide range of speeds and temperatures. A turbine is subject to large efficiency variations when running off its optimum speed and at temperatures varying widely from the design point.

6. Reversibility and equal efficiency when running in either direction. The turbine is efficient when running in only one direction. Reversing the turbine necessitates either moveable inlet guide vanes or partial admission nozzles, and heavily compromised blade shapes on the rotor.

7. The air motor is compact, embodying its own manifolding in a small, narrow envelope. The turbine requires large auxiliary manifolding and a larger basic diameter; a shape extremely difficult to work into the usual annular envelope available.

8. Simplicity. It is easy to machine the shapes necessary to produce the unit of the high-temperature steels required for operation at the temperatures encountered. The turbine requires accurate aerodynamic shapes, considerably more difficult and costly to make.

9. The air motor does not have high bearing loads, high bearing speeds, or difficult balancing problems.

(Paper "Air Motor Powered High Temperature Actuation Systems" on which this abridgment is based is available in full in mulitlith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Points Out Increase In Production, Testing

Based on talk by

E. H. SIMPSON
Hughes Aircraft Co.

(Presented before SAE Texas Section)

PRODUCTION and testing facilities for military electronics equipment are increasing in number and complexity these days. Since the complexity of this equipment is increasing at such a high rate, reliability requirements must also be intensified. Hence, the amount and techniques of testing corresponding in this increased production must be stepped up to insure successful equipment operation in the field.

Close relationship between testing and production should be maintained. Plants should be planned, laid out, and instituted around the knowledge of the overall requirements of production and testing. For example, lot control and process control afford flexibility of test facilities as well as good manpower utilization. Multiple assemblies are manufactured and tested on the same lines with easy changeover being accomplished in a short time. In-line assembly and test methods take full advantage of space, with the net result that higher yield accompanies ease of material handling.

In addition, test facilities and test methods as they relate to manufacturing schedules are closely allied to determine the number of personnel necessary to test for product acceptance. Thus, technicians must be trained, and standardized methods of measurement must be established.

S·A·E CEP
COOPERATIVE ENGINEERING PROGRAM NEWS

Dipstick Markings For Crankcase and Transmission Gain Society Approval

IMPROVED legibility molded the requirements of SAE's new Recommended Practice on Crankcase and Transmission Dipstick Marking. The new recommendations include the following:

- Raised or depressed lettering
- Simple block type characters
- Size and placement of lettering
- A portion of the dipstick shall be provided for where surface finish treatment may be effected for maximum oil level legibility. (See Fig. 1)

Dissatisfaction with dipstick readability and interpretation on the part of service station people prompted SAE's Engine Committee and Transmission Committee to undertake jointly the American Petroleum Institute request to standardize crankcase and transmission dipsticks.

Currently, there are as many different kinds of dipsticks as makes of cars. Instances have been sighted when poor interpretation of dipstick markings have lead to over or under filling. Illegibility has also lead to crankcase oils being added to transmissions and vice-versa.

Dipstick Survey

A 1956 production car dipstick study revealed the need for better oil level readability. (See Fig. 2.) Chrome-plated dipsticks appear to provide the worst possible contrast. Shiny cold-rolled surfaces and blue oxide coatings on spring steel ribbon-type sticks are also poor. Phosphate coated sticks are good texture-wise, but are poor in color.

Before dipstick surface treatment for oil level legibility can be recommended, further investigation will be necessary. A preliminary investigation was conducted by SAE's Dipstick Subcommittee.

Surface Treatment Tests

Here are the results of recent surface treatment tests made on sticks which were dipped into heated, new, relatively transparent 10 W motor oil:

Wrinkle Painted Dipsticks—A very definite demarcation line appeared on grey and black true wrinkle painted dipsticks. Sticks painted in light colors with a synthetic wrinkle paint provided an improvement over the flat-painted dipsticks, but the grey and black true wrinkle painted sticks showed even greater contrast. (See Fig. 3)

Dyed Oils—For a clear indication of oil level, aniline red dye mixed with oil proved to be highly satisfactory. When dyed oil was applied to wrinkle painted dipsticks, results were again highly satisfactory.

Anodized Aluminum—Blue and green give the best contrast when applied to a matte or embossed surface of anodized aluminum.

Flat-Painted Dipsticks — Dipsticks flat-painted in medium green and light blue showed the most contrast. Other colors tested which included light yellow, orange and red, became progressively unsatisfactory in that order.

Mechanical Device Readings — Grooves and slots in plain sticks did not improve visibility. One stick was drilled with a series of staggered .050 in. holes which provided fairly good contrast. However, it was felt that the holes would soon plug up and their usefulness decrease. The true wrinkle paints showed good contrast, but lighter paints did not appear to be improved by the presence of grooves. An acid etch was an improvement over the normal cold-rolled surface.

Plastic Dipsticks—Teflon was the only plastic material which might feasibly be substituted for metal dipsticks because of its resistance to high temperatures and corrosion. However, the plastics investigation was dropped because of the high costs involved.

This project was originally brought to light by Carl Georgi in a paper, "The Case of the Confusing Dipstick," presented before the American Petroleum Institute. Work was carried out by SAE under the leadership of K. L. Vogt of Ford Motor Co. who served as chairman of the Dipstick Subcommittee. Other participants were: T. M. Fisher, General Motors Proving Ground; H. L. Welch, Engine Development Laboratory, Chrysler Corp.

Copies of the Recommended Practice have been published as Technical Report No. 213, and are immediately available from SAE Headquarters. The Recommended Practice will appear in the 1958 Handbook.

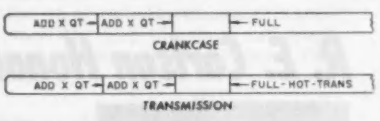


Fig. 1—New SAE recommendation for dipstick markings.

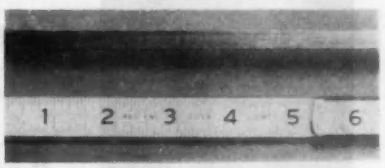


Fig. 2—1956 production car dipstick surface shows poor oil level legibility.

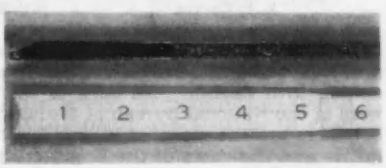


Fig. 3—Wrinkle painted dipsticks (specially prepared during an evaluation of surface treatment tests) provide good oil level readability.

Ordnance and Industrial Group Holds First Meeting

Opening the first meeting of the Ordnance and Industrial Subcommittee is Chairman L. P. Atwell (right) of Electric Auto-Lite. With him are (l. to r.) Tullio Tognola of the Scintilla Division, Bendix Aviation, and F. B. Esty of Wisconsin Motor Corp.

VARIOUS methods of measuring ignition system secondary voltages were presented at the first meeting of the new Ordnance-Industrial Subcommittee of SAE's Ignition Research Committee.

Basic requirements for measuring output voltage of high tension ignition systems were presented by Donald C. Loudon of Scintilla Division, Bendix Aviation, and J. F. Gage of Electric Auto-Lite. Points brought out by their reports follow.

- Output voltage waveforms of high and low tension magnetos for industrial use, outboard engine magnetos, and flywheel magnetos were covered.
- An oscilloscope in conjunction with a special high voltage divider was recommended for testing. Open circuit voltage magnitudes of waveforms may then be recorded on graphs. (The DuMont 304-A was used in tests at both Scintilla and Electric Auto-Lite. Scintilla also used the Tektronix 531.)
- A voltage divider having a ratio of approximately 300:1 will permit the relatively linear center portion of the oscilloscope tube to be used.
- 10,000 volts per inch was recommended as a basic calibration deflection.
- Capacitance dividers should provide good waveform reproduction throughout the desired frequency range. They should provide very high input impedance, and be completely shielded, stable, rugged, and small.

The new Subcommittee's first meeting was held June 4 during Summer Meeting at Atlantic City.

R. E. Carlson Honored As Sixteen-Year Chairman Of Lighting Committee

R. E. Carlson

AN engrossed certificate expressing the appreciation of SAE Lighting Committee members for 16 years of effective service as chairman was presented to R. E. Carlson, vice-president of Tung-Sol Electric. The presentation was made by V. J. Roper, who succeeds Carlson as Lighting Committee chairman, at an informal luncheon held in Newark, New Jersey, on May 21. John Warner, SAE general manager, whose association with Carlson goes back to the days following World War I when both were at the National Bureau of Standards, spoke briefly in a reminiscent vein.

Others present included Wilbur L. Cross, Jr., a member of the Lighting Committee and chairman of the Engineering Committee of the American Association of Motor Vehicle Administrators; Louis Rieben, D. A. Harper, M. R. Schulte, George Keown, R. K. Braunsdorff, and Larry Curtis, all of Tung-Sol Electric; and Don Blanchard, SAE staff secretary of the Lighting Committee.

Technishorts . . .

A CONTRACT FOR THE DEVELOPMENT OF 1000 F HYDRAULIC SYSTEMS has been awarded Republic Aviation by Wright Air Development Center. A fluid, seals, pumps, tube fittings, electrohydraulic valves, filters, and test equipment will be determined. Announcement of the undertaking was made at a recent meeting of SAE's Aircraft Hydraulic and Pneumatic Equipment Committee.

TRUCK-TRAILER COUPLING PROBLEMS, WITH PARTICULAR ATTENTION TO THE LOWER FIFTH WHEEL COUPLING, will be examined by a proposed SAE committee as a result of a Truck-Trailer Manufacturers Association request. The proposed committee will work on specifications for king pin materials, recommend installation techniques, and set up dimensions and tolerances for the lower coupler to complement previously established dimensions for king pins. The new committee will consist of members recommended by both the Truck and Bus Technical Committee and the Transportation and Maintenance Technical Committee.

DISCHARGE RATE OF STORAGE BATTERIES is being studied by a subcommittee of the Electrical Equipment Committee. Data will be based on 300 amp-hr, 0 F, recording 10-sec voltage, and minute time to 5-v end point for 12-v batteries not to exceed 80 amp-hr. The unrealistic character of the existing specification based on a 150-amp discharge rate for batteries of less than 80 amp-hr prompted the project.

SPLIT AND TUBULAR RIVETS, SOLID RIVETS, AND RIVET DESIGN SUGGESTIONS AND INSTALLATION TECHNIQUES are being evaluated by three new subgroups recently appointed by the Parts and Fittings Committee's Rivets Subcommittee. Hole sizes and depths will be studied to remedy problems presented by the 126 different diameter rivets which now exist in the small rivets classification.

Technical Board Hears Publication Policy Group

A Publication Policy Committee progress report was made to the Technical Board in Atlantic City, and it revealed the following.

A survey made of Handbook users indicated the vast amount of cross-referencing of Handbook material, and consequently, the need for more efficient page utilization if one book is to be maintained. Indications are that report complexity and the growth of the Handbook size are creating production and mailing problems, especially for foreign mailings.

To solve these problems and aid in classification of Handbook material (into standards, recommended practices, and information reports), a clear set of definitions are being finalized with the idea that they will serve as building blocks for developing reports in the future. A recommendation has also been made that technical committee chairmen carefully review existing material with the idea of possible elimination or compression of report information. In addition, a guide for report writers is nearing completion.

Tensile Strength Test For Seat Belts Now Required Over Body Block

THE tensile strength test for motor vehicle seat belt assemblies now requires that tests be made over a body block. This provision results from recent revisions of the SAE Recommended Practice. Although the straight tension test formerly prescribed has been eliminated, basic strength requirements have not been changed.

The report now states: "Belt assemblies should be mounted for test so that they will be loaded as nearly as practical as they would be stressed when installed in a vehicle in accordance with the belt supplier's instructions. If the belt supplier's instructions describe more than one method of installation, the laboratory in installing the assembly for test should be guided by the method which in its judgment results in the most adverse angular and dimensional relationships authorized by the supplier."

In view of the above and to simulate more accurately conditions of use, an appendix has been added to aid the laboratory in establishing angles to be used in seat belt testing.

Only single-occupancy belts are considered in the revised report. Previously, reference also was made to double-occupancy seat belts.

Copies of the revised Recommended Practice may be obtained from SAE Headquarters in New York.

Technical Committee Profiles

Oliver K. Kelley

CRANKCASE AND TRANSMISSION DIPSTICK MARKING and TEMPERATURE INSTRUMENT MOUNTING, a new Recommended Practice and Standard respectively, have been approved by the Technical Board. So states **Oliver K. Kelley,** chairman of SAE's Transmission Committee.

A passenger car automatic transmission test code which provides a reliable means of transmission comparison was completed only last year. This year, the Committee is working on truck transmission test procedures and requirements for seal rings, control springs, transmission friction materials, and a comprehensive description of automatic transmission functions and its mechanism.

Kelley, who is in charge of Transmission Development for General Motors Engineering Staff, also states that the Transmission Committee's first assignment on nomenclature and terminology for hydromatic drives (torque converters and fluid couplings), together with design definitions and symbols, has been completed after nearly five years of work.

Joseph Gurski

PROMPTED BY INCREASED ALUMINUM CONSUMPTION IN THE AUTOMOTIVE INDUSTRY, a thorough review and revision of the Wrought Aluminum Alloy Section of the SAE Handbook has been completed by the Nonferrous Metals Committee, reports **Chairman Joseph Gurski.**

Currently, the job of establishing industry-wide electroplating specifications is being wrestled with by the Electroplating Subcommittee. Since bright plated areas are increasing with every new car model, electroplating has assumed considerable importance. The Subcommittee is also working on specifications for anodized aluminum. Titanium and titanium alloys information is also being developed.

Increased attention is being focused on powdered metals. A subcommittee has been organized to consider the latest developments and to prepare standards for industry use.

In 1956, Gurski held the distinction of being chairman simultaneously of the Nonferrous Metals Committee and the Iron and Steel Technical Committee. He is assistant manager of the Process Development Department of Ford Motor Co.

W. W. Reaser

INCREASED DEMAND FOR THE APPLICATION OF THERMODYNAMICS IN BOTH THE MISSILE AND AIRCRAFT FIELDS has activated work on the Aircraft Applied Thermodynamic Manual by the Aircraft Air Conditioning Committee, states **Chairman W. W. Reaser** of Douglas Aircraft Corp. Since thermal thicket problems require a greater knowledge of thermodynamics, a concentrated effort is being made by the aircraft industry through this Committee to produce the proposed manual. If sufficient support is expressed by the aircraft industry, such a manual would reduce costs substantially for individual aircraft companies which might otherwise be forced to write their own manual.

Shutoff and check valves for air conditioning systems are also being studied by the Committee. Various accessory manufacturers and airframe companies are supplying data to help determine what current practices might best be standardized. Procedure standardization would greatly benefit the aircraft industry because of the great cost of test equipment.

About SAE Members

Graves

Spexarth

Alaback

Graham

Jones

Oakley

Strasser

Mohlie

WILLIAM H. GRAVES, professor of automotive engineering at the University of Michigan, has been elected vice-president of the American Forging & Socket Co., Pontiac, Mich.

Graves joined the faculty of the University of Michigan after 37 years service with Packard Motor Car Co. He served as vice-president in charge of engineering of Studebaker-Packard Corp. until May, 1956. In August of 1956, Graves was appointed a director of the American Forging & Socket Co.

An active member of SAE, Graves is a past-chairman of the SAE Detroit Section and has served as chairman of the Technical Board and SAE vice-president for Passenger Car Activity.

CHRIS SPEXARTH has been appointed chief engineer, Harley-Davidson Motor Co., Milwaukee. He has been with the company since 1931 as a designer, chief designer, and was made assistant chief engineer in 1943.

Spexarth has been a member of SAE since 1939 and served as Milwaukee Section chairman in 1953–1954.

C. JAMES ALABACK, formerly director of engineering, Marion (Ohio) Division of the Whirlpool Corp., has been made director of engineering, St. Joseph Division of the company.

HARRY J. GRAHAM has been appointed director of engineering for the Clinton Machine Co. Prior to joining Clinton Machine Co. this year, Graham was chief engineer at Lycoming, Division of Avco Mfg. Corp., Stratford, Conn.

T. CURRY JONES has been made manager of the newly established Mid-Atlantic Sales District of the Enjay Co., Inc., New York City. Formerly he was senior sales representative for the company's Akron district.

ROBERT G. OAKLEY, branch manager for the White Motor Co., Akron, Ohio, since 1954, has been named assistant to the vice-president in charge of the Autocar Division, White Motor Co., Exton, Pa.

ROBERT E. STRASSER has joined Fairchild Engine Division, Fairchild Engine and Airplane Corp., Deer Park, L. I., N. Y. as customer relations representative in the West Coast office in Hollywood, Calif. For the past four years he has represented the Stratos Division on the west coast as applications engineer.

Strasser is secretary of the SAE Southern California Section and has served, for several years, on the Governing Board.

J. R. MOHLIE has joined the Rich Mfg. Corp. of Battle Creek, Mich. as vice-president of engineering. Previously he was plant manager, Aviation Division, Oliver Corp., also of Battle Creek. Mohlie had served with the Oliver Corp. for almost 25 years, starting as development engineer and subsequently serving as plant manager for 11 years.

In 1954, Mohlie served as a member of the SAE Production Activity Committee.

BABOO RAM "BOB" TEREE has been named vice-president in charge of engineering and manufacturing of Greer Hydraulics, Inc., Jamaica, N. Y. Formerly Teree was chief engineer and manager of engineering and manufacturing for the company.

Prior to joining Greer, he was chief engineer of the Aircraft Division and Special Products Division, Weatherhead Co. He also has served as director of engineering of the New York Air Brake Co.'s Hydraulic Division.

Teree now serves as chairman of the SAE A-6 Committee, Aircraft Hydraulic and Pneumatic Equipment, Aircraft Accessories and Equipment Division.

WALLACE COLLETT has been made product sales manager, material handling department, Tractor Group, Allis-Chalmers Mfg. Co. Previously he was associated with the Tractor Group's training section at the home office in Milwaukee.

GEORGE E. HERRMAN, of Aluminum Co. of America, has been named manager of commercial automotive sales. Previously he was sales engineer at the Alcoa Detroit sales office.

PETER H. PONTA has been made general manager of the Engine Division, Ford Motor Co. Formerly he was manager, engine manufacturing, Engine and Foundry Division of Ford.

WILLIAM D. DUNN, assistant to the president, Oberdorfer Foundries, Inc., Syracuse, has been elected a national director of the American Foundrymen's Society.

Teree

Collett

Herrman

Ponta

Dunn

Acker

Scott

Burnett

Intemann

Jensen

Beyer

Jones

GEORGE H. ACKER has been elected president of the Cleveland Worm & Gear Co. and its affiliate, The Farval Corp.

Acker became associated with the company in 1923 and was named chief engineer in 1925. He was made vice-president in charge of engineering and production in 1942 and executive vice-president in 1952.

J. J. SCOTT has been named Detroit district manager of the Bound Brook Oil-Less Co. He will assume responsibility for all company operations from the newly-opened branch office. Previously Scott was Detroit sales engineer for the company.

WILLIAM E. BURNETT has been appointed executive engineer in the engineering office of the Edsel Division, Ford Motor Co. Since 1954 he has served as executive engineer in charge of Ford car engineering.

Burnett joined Ford in 1946 as experimental engineer in the Ford car department. He was named assistant chief engineer in 1949, and chief Ford car engineer in 1951.

HERMANN K. INTEMANN has been named president of Electro Metallurgical Co., Division of Union Carbide Corp.

Intemann joined Union Carbide in 1930 as a laboratory technician for the Halowax Corp. He was subsequently made New York sales manager in 1940 and moved to the Bakelite Co. in 1944 where he became vice-president and general sales manager in 1953. In 1956 he was made executive vice-president of Electro Metallurgical Co.

ROBERT G. JENSEN has been appointed chief engineer for Perfex Corp., Milwaukee. Previously Jensen was assistant chief engineer. In addition to his new position, he will work with research and development of heat transfer and allied products.

WALTER J. BEYER, formerly chief engineer, Perfex Corp., Milwaukee, has been named to the newly created position of manager of engineering for the company. His new responsibilities will include management, inspection functions, cost estimates, and interweaving of new products into the present operation.

DOUGLAS S. JONES has been named district manager by Roadway Express, Inc., covering the Chicago, Kansas City, Milwaukee, South Bend and St. Louis areas. Jones joined Roadway Express in 1952 as assistant superintendent of transportation and subsequently was made director of transportation.

CHARLES F. SANDERSON has become director of the Sanderson Motor Co. Pty. Ltd., Victoria, Australia. Previously Sanderson was director, S.A. Cheney Pty. Ltd., also of Victoria.

IGOR IVANOVITCH SIKORSKY, aviation pioneer, has retired as engineering manager of the Sikorsky Division of the United Aircraft Corp. He will continue with the company indefinitely as a consultant in the division named after him.

Although the division specializes in helicopters, Sikorsky is noted for other aviation achievements. He flew the first successful helicopter in this country in 1939.

Prior to this, he had built and piloted the first multi-engine plane in 1913. He also designed, built and piloted the first all-metal transport plane, forerunner of the modern airliner. Other projects include the building of "flying boats" that pioneered ocean routes which are still being used by airlines.

REGINALD A. SHEWRY has been made associate engineer, Engine Oils and Gear Lubricants, Armour Research Foundation of Illinois Institute of Technology. Prior to his new post, Shewry was field engineer, technical service department, the Pure Oil Co.

He served with the Armour Research Foundation from 1942 to 1951, when he became associated with the Pure Oil Co.

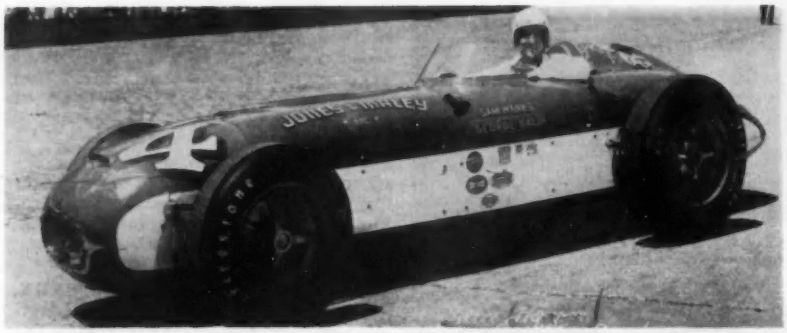
HERBERT M. PERKINS, formerly development engineer, G-V Controls Inc., has been made project engineer for the company.

PAUL G. MOYER has been named engineering technician, missile section, Bendix Products Division, Bendix Aviation Corp., White Sands Proving Grounds, N. Mex. Previously Moyer was field evaluation engineering technician for the company.

DARIO R. GROSS is now a trainee engineer with Cummins Engineering Co. Previously, he was with the Department of the Army.

DURWARD B. ERMINGER is now motor truck consultant, southwest region, International Harvester Co. Previously, he was divisional product consultant for the company.

CHARLES K. ALEXANDER, JR. has become a manufacturer's agent, the Alexander Co., Milwaukee. Formerly he was sales representative, Universal Oil Seal Co., Pontiac, Mich.



SAM HANKS, veteran auto-racer, was the winner of the 1957 Indianapolis 500-Mile Auto Race. The official winning time was 3 hours and 41 minutes 14.25 seconds, clocking an average speed of 135.601 mph.

Hanks has been running in the Indianapolis race since 1940, finishing third in 1952 and 1953. Last year he placed second in the 500-mile race in the car shown above. Upon completion of the 1957 race, Hanks announced his retirement.

COL. WILLARD F. ROCKWELL, chairman of the Association of the U. S. Army, heads the first single organization to serve the professional and public relations needs of the officers and men of the Army. Prior to the organization of AUSA in 1955, there were several Army service groups, but no representative group to meet the needs in military and civilian circles comparable to the Air Force Association and the Navy League. The AUSA is composed of regular Army personnel, former servicemen, and interested citizens.

LT. COL. FRANCO E. FIORIO is now director, USA Division, Cebtro Aeronautico and Atomico Italiano. Fiorio represents the CAAI as a correspondent for three Italian aviation magazines. Previously he was serving with the Italian Air Force, stationed at the Italian Embassy, Washington, D. C.

LIEUT. GEN. LAURENCE C. CRAIGIE, USAF (Ret.), has received the Italian decoration, Grande Ufficiale Al Merito Della Republica Italiana for his assistance in the expansion of the Italian Air Force in 1954–55. At this time, Craigie was commander-in-chief of the Allied Air Forces, Southern Europe.

Craigie now serves as long-range planning assistant to the defense products vice-president, American Machine & Foundry Co.

YUNUS UNAL has been made a laboratory engineer in the Detroit Diesel Engine Division, General Motors Corp. Previously he was working in layout with GMC.

ROBERT S. TREMBATH has joined Whirlpool Corp. as development engineer, advanced design. Formerly he was senior project engineer, Buick Division, General Motors Corp.

ROBERT W. PHILLIPS has been appointed chief engineer of synthetics and plastics in the Research and Development Division of Flexonics Corp., Maywood, Ill. Formerly Phillips was chief engineer of the company's Flex-O-Tube Division, having held that position prior to acquisition of the division by Flexonics Corp.

NICHOLAS H. DEVLETOGLOU is now stationed in Athens, Greece, with the army. Prior to his relocation he was junior design engineer, Babcock & Wilcox Co., Newark, N. J.

LEF W. KENYON is now project engineer, Automotive Test Division U. S. Army Ordnance Test Activity, Yuma Test Station, Yuma, Ariz. Prior to this post, Kenyon was chief, Operations Branch, Office, AC of S. Logistics, Dept. of Army, Aberdeen Proving Ground, Md.

WARREN H. CHASE has transferred as plant manager to the Cleveland Graphite Bronze Co.'s Bridgeport, Ohio plant in the Greater Wheeling, W. Va. area. Previously he served at the company's Ft. Wayne operation as plant manager.

JACK M. ANGEVINE has joined Sundstrand Aviation, Denver, Colo., as project engineer. Formerly he was research engineer, Caterpillar Tractor Co., Peoria, Ill.

BRUCE D. NEWMAN has been named secretary of the Barber-Green Canada, Ltd., Toronto. He is also chief engineer and assistant to the president. Formerly Newman was manager, engineered sales, for the company.

HAROLD R. FISHER is now a research engineer at the research center, Borg-Warner Corp. Previously, he was an instrumentation engineer at the company's products development laboratory.

SAE Father and Son, **DR. EDWARD R. SHARP** (right) and **EDWARD G. SHARP** (left), pose for a Journal photograph. Dr. Sharp is director of the NACA Lewis Flight Propulsion Laboratory, Cleveland. His son, Edward G. Sharp is general manager, Jarvis Mfg. Corp., Middletown, Conn.

Dr. Sharp has been a member of the SAE Cleveland Section since 1946 and his son has recently joined the Southern New England Section.

STEFAN PRONASKO has joined the Rocketdyne Division of North American Aviation, Inc., Canoga Park, Calif. as research engineer. Previously he was supervisor, engine testing unit, quality control department, Engine and Foundry Division, Ford Motor Co.

JACK R. STITT has been made coordinator of marketing, Oronite Chemical Co., San Francisco. Prior to this post, Stitt had served as eastern region manager and chemical additive sales manager for the company.

JOSEPH KIM has joined the Utica-Bend Corp. of South Bend, Ind. as manager of manufacturing engineering. Formerly he was with the Curtiss-Wright Corp. on the general manager's staff in the Wright Aeronautical Division.

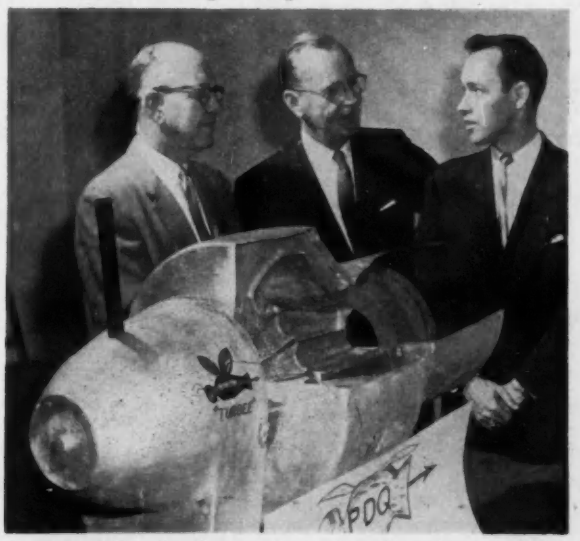
JAMES THORNTON is now zone service engineer with Detroit Diesel Division, General Motors Corp. Previously, he had been a service engineer for the company.

RAY GROSE has joined Chaso Tool Co. Inc. as vice-president and general manager. Previously, he was sales manager for the Lock Thread Corp. in Detroit.

E. T. HERGENROETHER has retired from the International Nickel Co., New York City. He had served as a metallurgist with International Nickel.

DONALD ALBERT BODLEY is now with the traffic department of the Board of Missions of the Methodist Church. Formerly he was a foreign missionary for the organization.

SAE COUNCILOR WILLIAM K. CRESON (center) is donor of the James Louis Creson Memorial Trophy, awarded this year for the first time to a team of engineering students at Purdue University's School of Aeronautical Engineering.



Team competition for design of an aircraft engine has become an annual project in the aircraft engine design class taught by **PROF. JOSEPH LISTON,** an SAE member since 1935. The competing teams present their designs to an 8-man board of judges representing "management" of an aircraft engineering company.

Creson, who has established the trophy award in memory of his father, was chairman of the "management" group of judges. Like Creson, who has had a long and distinguished engineering career with Ross Gear & Tool Co., most of the other judges were leading industry engineers. One of them, **W. B. BARNES,** president, Barnes Motor Development Co., is also an SAE member, as is **BRUCE ELROD,** civil engineering professor of Purdue.

Working conditions for the competing design teams are made to simulate industry as nearly as possible. The students spend an entire semester preparing their proposals to present to "management."

Fred J. Collins (right) was chief engineer of the winning student team. The winning engine this year was a helicopter engine, named the Turbee.

Teetor Prosser

RALPH R. TEETOR, SAE President in 1936, has retired as president of the Perfect Circle Corp., Hagerstown, Ind.

Teetor joined the company in 1912, became director of engineering in 1919, and vice-president in 1938. He was elected to presidency in 1946.

Teetor will continue as a director of the company and maintain an active association with the business, especially on new product development projects.

WILLIAM B. PROSSER has been elected to succeed Ralph Teetor as president of Perfect Circle. He has been with the company for 32 years.

Prosser joined the company in 1928 in sales and subsequently became manager of manufacturers' sales. During World War II, he organized and managed the company's Richmond, Ind. plant which was built to produce piston rings for the Army, Navy and Air Force.

In 1943 Prosser was named general factory manager and four years later appointed general manager. He was elected vice-president in 1951, and a director in 1956. In addition, he is board chairman of The Perfect Circle Co., Ltd. of Toronto, and Centrifugal Foundry Co. of Muskegon, Mich., two wholly-owned subsidiaries of Perfect Circle.

DAN C. TEETOR was reelected vice-president at the annual organizational meeting.

HARRIS SAUNDERS, JR., formerly in the U. S. Navy, has joined the Saunders System Corp. of Birmingham, Ala. as executive vice-president.

J. ALFRED BAGNALL, previously field engineer, has been made district manager, Spencer Thermostat Division, Metals and Controls Corp., Attleboro, Mass. He now represents Spencer Thermostat Division in all problems of selling, field engineering, application, service, credit, deliveries, follow-up, and related fields.

Continued on page 116

SAE national west coast meeting

olympic hotel
seattle, washington
august 12-16, 1957

monday, aug. 12

sessions covering: aircooled diesel engines; automotive driving axles; friction brake limitations

tuesday, aug. 13

papers discussing: off-highway transmissions; automatic transmissions in heavy-duty trucks; lubricant recommendations for logging equipment; and multipurpose lubricants

wednesday, aug. 14

subjects including: factors affecting high truck fuel economy; air cleaners; trailer symposium

thursday, aug. 15

paul bunyan day . . . featuring an all-day trip for inspection of mill and logging operations and equipment, followed by a tour of Pacific Car and Foundry.

friday, aug. 16

morning and afternoon sessions for the presentation of papers on smog problems and elimination devices

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SAE National Meetings

1957

August 12-16
West Coast Meeting
Olympic Hotel, Seattle, Wash.

September 9-12
National Farm, Construction and Industrial Machinery Meeting and Production Forum

September 30-October 5
Aeronautic Meeting, Aircraft Production Forum, and Aircraft Engineering Display
Ambassador, Los Angeles, Calif.

November 4-6
Transportation Meeting
Hotel Statler, Cleveland, Ohio

November 5-6
Diesel Engine Meeting
Hotel Statler, Cleveland, Ohio

November 6-8
Fuels and Lubricants Meeting
Hotel Statler, Cleveland, Ohio

1958

January 13-17
Annual Meeting and Engineering Display, The Sheraton-Cadillac and Statler Hotels, Detroit, Mich.

March 31-April 2
Production Meeting and Forum
The Drake, Chicago, Ill.

March 4-6
Passenger Car, Body, and Materials Meeting
Sheraton-Cadillac Hotel, Detroit, Mich.

April 8-11
Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display
Hotel Commodore, New York, N. Y.

June 8-13
Summer Meeting
Chalfonte-Haddon Hall
Atlantic City, N. J.

SECTIONS

JULY 1957

Section's Plus-Features Increase Benefits for Members

SAE Sections are now spearheading a campaign to fulfill to the letter the SAE Section Philosophy which holds that the object of SAE Sections and Groups is to generate activities which:

1. extend the Society's benefits to members in their local areas
2. further the Society's objectives as indicated by its Constitution, particularly with respect to maintaining a high level of technical quality.

The new thought in Sections is that a satisfactory job, i.e., providing members with a series of good technical meetings topped off, perhaps with a social event, is not enough.

Section chairmen and Meetings chairmen now are thinking in terms of "meeting appeal", meetings with a special twist which will culminate in increased benefits to members.

Some of the additional services which have clicked include: lecture series, conferences, package meetings, seminars, panel meetings, three-ring circus meetings, member meetings, and meetings to members.

Lecture Series

Six years ago some of the **Milwaukee Section** officers saw a need in their area for a source of basic information on engine design. With fingers crossed they lined up six top men to present a series of lectures on "Engineering Know-How in Engine Design."

The turn-out was good; the lectures well received; and the lecture series, still built around the theme "Engineering Know-How in Engine Design", has become a feature of the Section.

Conferences

The **Central Illinois Section** calls its outstanding three-day meeting, "The Earthmoving Industry Conference." This is a Section meeting of National Meeting caliber. From start to finish, Section members run the meeting; they set up the program, secure speakers, make hotel arrangements, send out announcements, secure projection equipment, and run the banquet.

The Section saw a need for an earth moving industry meeting, and industry has given it full support—both by sending men to attend the meeting and by underwriting expenses.

Package Meetings

Popularized by the **Texas Section**, the Package Meeting is, in effect, a part-day conference with experts presenting papers in a specialized area.

The Section holds two special meetings a year, an Aircraft Production Meeting and an Airconditioning Meeting. Each meeting starts at four in the afternoon with a technical session, takes time out for a social period followed by a dinner and a crackerjack dinner speaker, then reconvenes for a concluding technical session.

The term "Package Meeting" is applied because it is hoped that all who attend will stay through the whole meeting. A member must buy a ticket to attend, and the price of the ticket includes the cost of the dinner.

Seminars

Seminars have a stronghold in **Southern California Section.** Two or three meetings are scheduled on consecutive nights under leadership of experts in a given field—the idea being to pretty well exhaust available information on a given topic.

Several pointed advantages to seminars are first, a number of seminars on different subjects broaden the scope of member interest and second, specialists like seminars—they have high appeal in areas where many members are engaged in specialized engineering assignments.

Panel Meetings

Metropolitan Section juniors wanted more technical meetings than were provided at regular dinner meetings. This brought about non-dinner technical sessions on specialized topics—with emphasis on discussion periods. One or two are held each meeting month and on occasions are taken to membership centers away from the regular meeting area.

Three-Ring Circus Meetings

Originating in the **Detroit Section**, the Three-Ring Circus meetings are designed to get members concerned with different technical interest areas together for dinner and then to separate them for meetings on specialized topics.

This type of meeting would appear to be a possible answer to problems faced by Sections with two or more segments of their membership interested in widely divergent fields.

Member Meetings

At least two Sections, **Twin City** and **Central Illinois** encourage their members to prepare and present papers at special "Member Meetings."

Topics usually have to do with developments, researches or tests with which the speakers are identified. Two or three twenty-minute papers usually constitute the bill.

Programs such as these are excellent ways to encourage younger members to participate in meetings and take part in discussions.

Meetings to Members

Some Sections have concentrations of members who are located beyond what might be considered convenient travel distance for meeting attendance.

One answer to this problem is to hold regular Section meetings in several membership centers during the year. Another solution is for local groups to be given Section authorization to hold regular or occasional meetings in their cities.

The purpose is to extend Section service to members located at some distance from the Section Headquarters cities—to take meetings to them if they cannot come to the meetings.

1. Three main speakers at the Twin City Section's May 8 meeting are American Hoist and Derrick Co. officials (top to bottom) Lee Coulter, sales manager; Joseph Hite, director of engineering; and R. J. Stoddard, executive vice-president.

2. Prior to a plant tour of the American Hoist and Derrick Co. facilities in St. Paul, 1957–1958 Twin City Section Chairman Donald D. Hornbeck (left) presented a certificate of appreciation to 1956–1957 Twin City Section Chairman S. H. Knight who is fleet manager, Northern Pacific Railway Co.

3. St. Louis Section Vice-Chairman for Transportation and Maintenance Ralph Cornel (right) joins May meeting guest speaker Capt. D. L. Steele (center), Federal Barge Lines and Wren Malone (left), vice-president, Engineering Controls Inc.

4. St. Louis Section Chairman Henry Buelt (right) presents a 25-year membership award to J. M. Sunnen (left), president, Sunnen Products Co.

5. SAE Student Branch members from the University of Illinois and Bradley University gather to present papers at the April 29 meeting of the Central Illinois Section.

Joining in the round of handshakes are (left to right) Bradley Faculty Adviser Max A. Wessler; James R. Shure, U. of Illinois; Hubert C. Edfors, technical chairman from the U. of Illinois; A. Cannon, first place winner from the U. of Illinois who spoke on "Methods to Improve the Fuel Economy of Passenger Cars"; Alvin D. Mayerchin, technical chairman from Bradley; Stanley Wallis, second place winner from Bradley who spoke on "Fuel Injection in Passenger Car Engines"; John Dickerson, Bradley; and U. of Illinois Faculty Adviser W. L. Hull.

From Section Cameras

1. Alberta Group 1956–1957 Chairman Frederick G. Forster (right) accepts a certificate of merit for outstanding service during his term of office from Harry Dawson of Wilson Equipment Co. and a past-chairman of the Section, at the May 17 meeting.

2. Roy E. Marquardt (right), president of Marquardt Aircraft Co. and guest speaker at the April 27 meeting of Northrop Aeronautical Institute SAE Student Branch, listens as E. MacLaren, a student at the Institute, expounds a bit.

3. Capt. L. A. Aitken (left) accepts the 1957 Mac Short award in behalf of his brother A. James Aitken, who, upon graduation from California Polytechnic College, was called to activity with the U. S. Army. Presenting the award is 1956–1957 Section Chairman John R. Schmitt while Dick Short (center right) and 1957–1958 Section Chairman John C. Buckwalter look on.

4. Jeff Frazer (left), Program chairman for Northern California Section's South Bay Division, introduces speaker Willie A. Fielder, Lockheed Aircraft Corp., at the June meeting.

5. Texas Gulf Coast Section Governing Board members enjoy an observation made by R. C. Marr, delegate to the SAE National Nominating Committee, at the June meeting of the Board at which time the outgoing officers briefed the incoming officers concerning their duties and responsibilities.

Considerable stress was placed on increasing the Section's activities in connection with student activities, attendance at meetings, and particularly increasing membership.

Of, By, and For the Ladies

Petticoats predominated at the Mid-Michigan Section's May 6 meeting when Miss Mary Huck, director of Home Economics, Frigidaire Division, General Motors Corp., addressed the Ladies' Night guests on "Slide Rules and Petticoats."

Miss Huck's talk dealt with the homemakers' influence in the development of new products for the home, and the problem encountered by engineering to keep pace with the demands for better appliances.

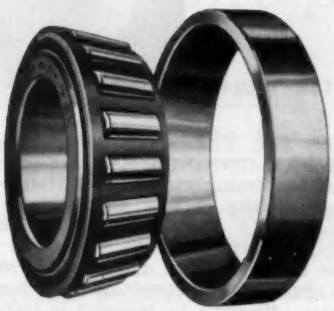
1. **Inspecting the "appliances of the future" display during the Mid-Michigan Section Ladies' Night are Mr. and Mrs. J. Robinson.**

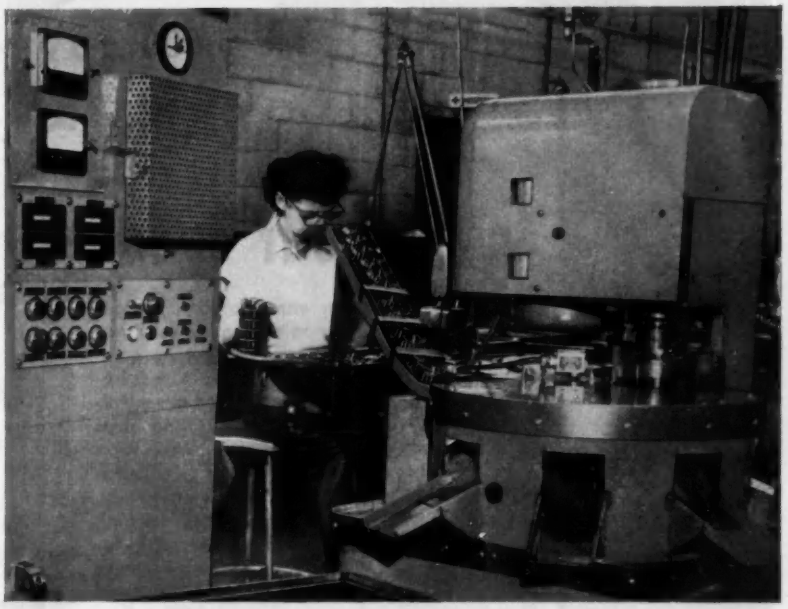
2. **Mid-Michigan Sectioneers and members of the distaff side scrutinizing the dream kitchen are (left to right) Mr. and Mrs. Henry Smith and Mr. and Mrs. Philip B. Zeigler.**

3. **Special guest Miss Mary Huck (right) takes a dinner break with Mrs. Howard Roat and Mid-Michigan Program Chairman Howard Roat.**

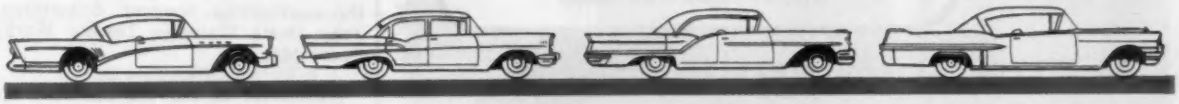
4. **Banding together are (left to right) E. R. Wilson, Jr., Mid-Michigan chairman; Howard Roat, Program chairman; Harry S. Golden, delegate to SAE National Nominating Committee; and Philip B. Zeigler, Section Secretary.**

When you think of tapered roller bearings think of HYATT





Automatic electronic noise and torque test machine



—because they're built with ELECTRONIC QUALITY CONTROL!

The photo above shows something *new and important* to every user of tapered roller bearings. At HYATT'S plant in Clark Township, New Jersey, batteries of electronic controls like this are helping HYATT craftsmen turn out tapered bearings with *greater uniformity than ever before achieved in quantity production.*

HYATT'S new standards of *electronic quality control* mean longer, smoother, more dependable performance than any tapered bearings —even HYATTS—have ever given you in the past. If you want the *best*, you want HYATT Hy-Roll Tapered Bearings! Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

Nearly half of all American cars and trucks built today have HYATT Hy-Roll Tapered Bearings

GM GENERAL MOTORS

HYATT HY-ROLL BEARINGS FOR CARS AND TRUCKS

For pressures to 5,000 psi
STRATOFLEX
HOSE and FITTINGS
meet your specs
When you design with Stratoflex you get more than the vibration and stress resistance inherent in flexible hose. You get hose fittings designed to meet your specific requirements. Stratoflex hose and fittings are available in a wide range of types and sizes . . . lightweight for aircraft use . . . corrosion resistant for marine applications . . . Teflon* for extremely high or low temperatures . . . heavy duty, double-wire braid types for high pressure. Stratoflex leak-proof, reusable fittings make possible quick, easy replacement or modification. You simplify both design and maintenance when you specify Stratoflex.
*TEFLON is a registered DuPont trademark.
TYPICAL ASSEMBLIES
SF 212 DOUBLE WIRE BRAID HOSE with SF 320 REUSABLE SWIVEL FITTING for high pressure applications. Working pressure range: 1,125 to 5,000 psi.
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SF 124 TEFLON HOSE with SF 524. SWAGED FITTING for aircraft applications. Stays flexible from −100° to +450° F. Unaffected by all fuels, petroleum, synthetic base lubricants, acids, and solvents.
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About SAE Members

Continued from page 109

Jennings

HENRY JENNINGS, SAE vice-president for Transportation and Maintenance Activity, is now district representative for the Thompson Trailer Corp., Pikesville, Md.

He is working out of New York on the application of low loaders in fleet service. Recently he resigned as technical editor of *Fleet Owner*, McGraw-Hill Publishing Co., Inc.

PHILIP R. BUNNELLE has joined the central engineering department, Food Machinery and Chemical Corp. as senior design engineer. Formerly, he was a junior design engineer with the engineering research department, John Deere Waterloo Tractor Works, Deere Mfg. Co.

HERBERT H. BOWIE has been appointed manager of military sales for Williamsport plant, Lycoming Division, Avco Mfg. Corp. Bowie has been with the Lycoming Division for three years, formerly having been located at the Stratford, Conn. plant as staff sales representative.

VINCENT P. MASI has joined Chrysler Corp. as manufacturing manager at the Mound Road Engine Plant, Detroit, Mich. Previously Masi was manager of manufacturing engineering with Ford Motor Co.

JAMES JACKSON DUGGAN has been named quality control engineer, Mercury Division, Ford Motor Co. Formerly he was chief inspector, Marmon-Herrington Co., Inc., Indianapolis.

CHARLES A. BENDER, JR. has joined Gulf Oil Corp. as district manager in Hattiesburg, Miss. Previously, he was assistant district manager for Fairbanks-Morse Co.

CARLOS A. CLAURE is now a mechanical engineer with Bauer Brothers Co., Springfield, Ohio. Formerly, he was assistant superintendent, Bolivian Oil Co.

Continued on page 118

Bridgeport Aluminum Shapes

put extra pay in payload... extra profit in production

BRIDGEPORT EXTRUSIONS ARE LIGHTWEIGHT, STRONG *—for extra payload profits, more compact assemblies*

AVAILABLE IN A COMPLETE LINE OF STANDARD SHAPES *without die charge*

DURABLE AND ATTRACTIVE - *resist corrosion, always good-looking, no maintenance problems*

MADE TO EXACT TOLERANCES—*assure rigid, weathertight fits—easy to handle and assemble*

AND YOU GET THESE EXTRAS, TOO, with BRIDGEPORT *• "Big producer" capacity • Experienced technical help • Consistent high quality • Service that is unsurpassed*

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NEW ALUMINUM EXTRUSIONS BOOK

Write on your letterhead for Bridgeport's new Aluminum Extrusions Handbook—a 130-page manual with complete sections on truck and trailer construction, full size shapes available, data, limits and tolerances.

ROOF RAILS—BRIDGEPORT extruded sections always fit perfectly, make assembly fast and easy.
SIDE POSTS—for exterior post or smooth side construction—provide strong, weathertight body.
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For the very newest in

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MECHANICAL ENGINEERS WANTED!

Development work on

PRESTONE BRAND ANTI-FREEZE

How knowledgeable are you on heat transfer in cast iron or aluminum engines? What about relating engine performance on the dynamometer to actual road test data?

Interested? These are some of the projects relating to PRESTONE being conducted at our engineering center at Tonawanda, New York. Other projects range from evaluations of new automotive products such as gasoline and oil additives to development of new test procedures for high output automotive engines.

Because this is one of the major research and development centers of Union Carbide Corporation, an exceptionally wide range of technical facilities are available. Working conditions are pleasant in the modern technical center, staffed by more than 350 creative men of scientific background. The salary program is liberal, and complete employee-benefit plans are in effect.

Men with Bachelor or Master Degrees, with a high degree of individual creativeness and initiative, are required. Please send a summary of your educational background and work experience to Mr. R. P. Kalle, Dept. MEA, Linde Company, Division of Union Carbide Corporation, P.O. Box 44, Tonawanda, N. Y.

50 YEARS OF LEADERSHIP

Linde UNION CARBIDE

The terms "LINDE," "PRESTONE" and "UNION CARBIDE" are registered trade-marks of UCC.

About SAE Members

Continued from page 116

Johnson Donoho

JOSEPH C. JOHNSON is now assistant manager-engineering in charge of the newly created advanced engineering section, American Bosch Division, American Bosch Arma Corp. Previously Johnson was assistant chief engineer in the electrical engineering section of the company. Before joining American Bosch Johnson was associated with Titeflex Inc. as manager of research and development.

CHARLES C. DONOHO, chief metallurgist, American Cast Iron Pipe Co., Birmingham, Ala., has received the Peter L. Simpson 1957 Gold Metal Award of the American Foundrymen's Society. He was cited "for outstanding contributions to the Society and to the Ferrous Castings Industry, especially in the fields of Gray Iron, Nodular Iron and Steel."

HELMER PETERSON has rejoined Mack Trucks, Inc. as director of production at the Mack Sidney, Ohio Division.

Peterson was general manager of operations for Mack in 1953, in charge of the company's plants at Allentown, Pa., Plainfield and New Brunswick, N. J. He later resigned to become plant superintendent for the A. P. Smith Mfg. Corp., where he served for three years.

JERZY CICERO-PIENKOWSKI has joined the Chevrolet Division of General Motors Corp. in Buffalo as a tool designer.

KEITH VAN KIRK has been made branch manager of the Magnaflux Corp., Chicago. Previously he served as branch manager, Detroit branch, for the company.

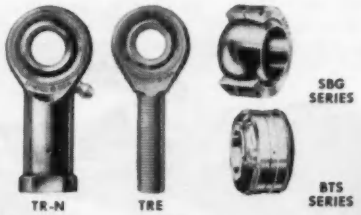
ARTHUR J. TRACHSEL is now industrial representative for the states of Oregon, Washington, and Montana for Federal Mogul Service of Portland, Oreg. He will cover distributor sales and original equipment manufacturers. Formerly he was sales representative for the Bearing Sales and Service, Inc.

Continued on page 121

YOU CAN DEPEND ON SPHERCO®
BEARINGS & ROD ENDS

Quality SPHERCO Bearings and Rod Ends are precision built for superior performance

There are SPHERCO Bearings and Rod Ends for every application! There is a SPHERCO Engineer in your area to help you with your problems.



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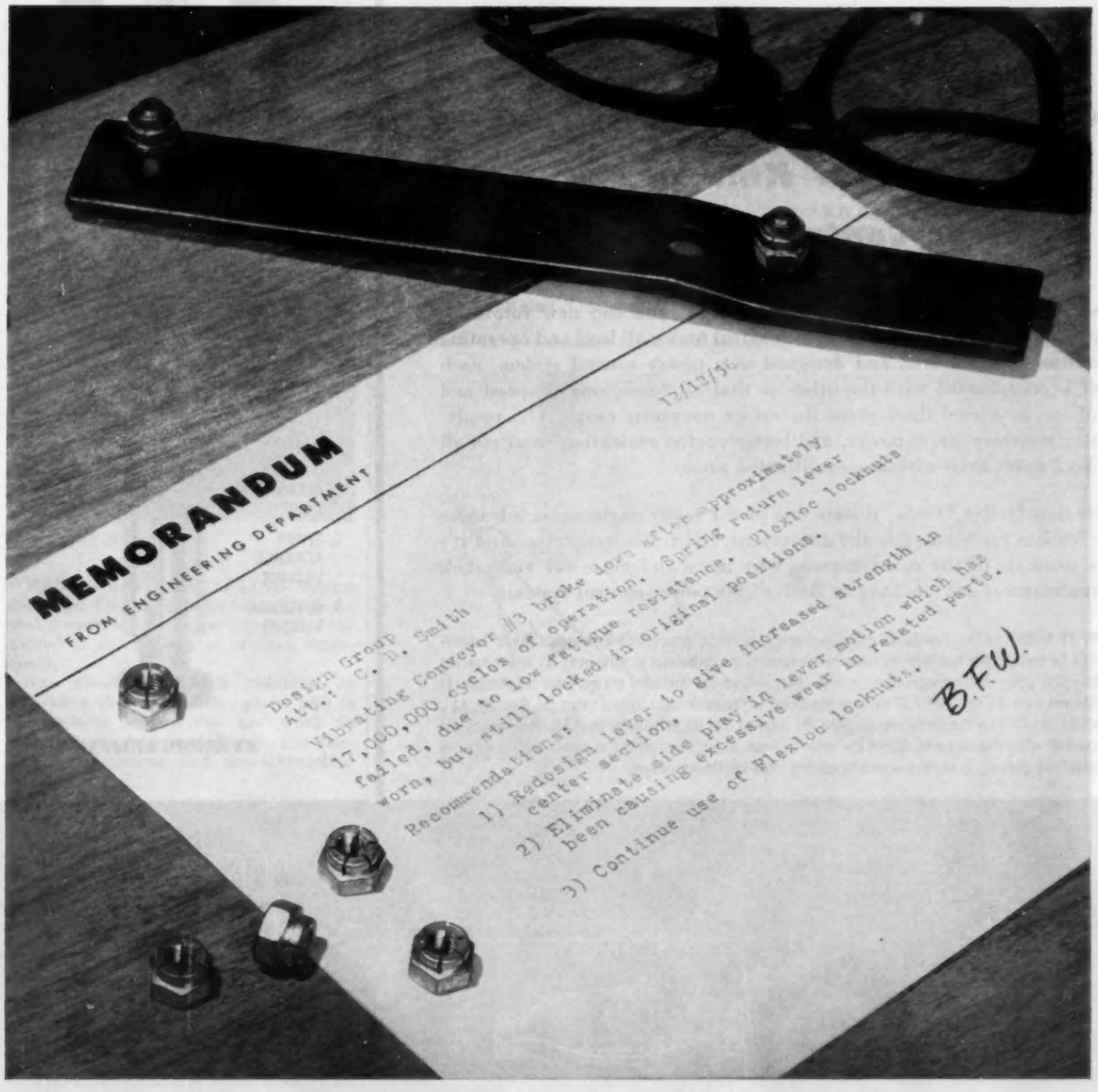

MEMORANDUM
FROM ENGINEERING DEPARTMENT
12/13/56
Design Group
Att.: C. D. Smith
Vibrating Conveyor #3 broke down after approximately
17,000,000 cycles of operation. Spring return lever
failed, due to low fatigue resistance. Flexloc locknuts
worn, but still locked in original positions.
Recommendations:
1) Redesign lever to give increased strength in
center section.
2) Eliminate side play in lever motion which has
been causing excessive wear in related parts.
3) Continue use of Flexloc locknuts.
B.F.W.

Why designers specify FLEXLOC self-locking nuts

Where products must be tough . . . must stand up under vibration, shock and abuse . . . designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts as fasteners.

HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting spring tension in the flexible locking collars. And they are reusable: rough screw threads, repeated removal and replacement, frequent adjustments will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes and materials, to meet the most critical locknut requirements. Your authorized industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 55, Pa.

STANDARD PRESSED STEEL CO.

FLEXLOC® LOCKNUT DIVISION

SPS

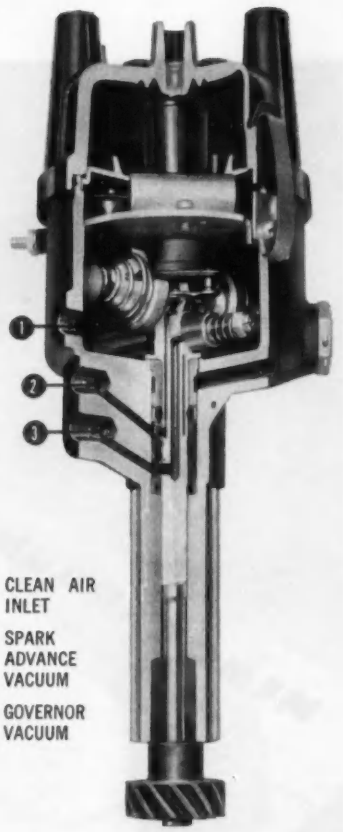
JENKINTOWN PENNSYLVANIA

How Holley Teams Carburetor — Governor — Distributor For a New Kind of Power Control System

The Holley "team" of carburetor, governor, and the new rotovance distributor provides positive engine control under all load and operating conditions. Engineered and designed as a power control system, each unit is coordinated with the other so that all conditions of speed and load are measured throughout the entire operating range. The result: better economy, more power, and better engine regulation from cut-off to load point than with non-coordinated units.

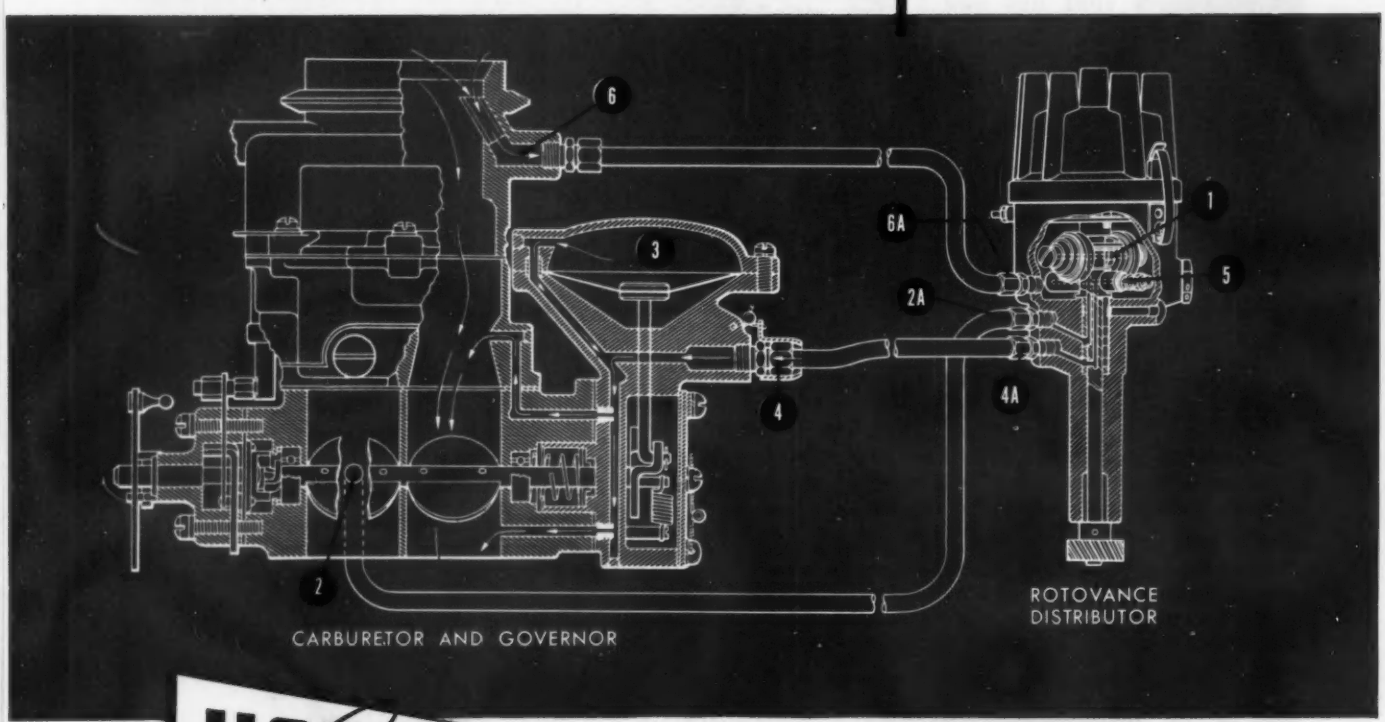
This new Holley "team" is only one of the many engineering advances Holley has contributed to the automotive and truck industries. And it's one example of the many reasons why more and more car and truck manufacturers are "looking to Holley" for power control systems.

HOW IT WORKS: The distributor centrifugal spark advance, determined by weights (**1**) is supplemented for part throttle operation by vacuum measured at the carburetor throttle body (**2**) and connected to the spark advance diaphragm through inlet (**2A**). Vacuum for operating the governor diaphragm (**3**) is obtained from the carburetor at (**4**) and connected to the centrifugal control valve (**5**) through (**4A**). Clean air, drawn from the carburetor air horn (**6**) is taken into the distributor at (**6A**). Governing is accomplished when engine speed causes the valve to close, which shuts off the air bleed and permits the vacuum from port (**4**) to develop a throttle closing force on the diaphragm.



1. CLEAN AIR INLET
2. SPARK ADVANCE VACUUM
3. GOVERNOR VACUUM

NEW ROTOVANCE DISTRIBUTOR



CARBURETOR AND GOVERNOR

ROTOVANCE DISTRIBUTOR

HOLLEY Carburetor Co.

FOR MORE THAN HALF-A-CENTURY—ORIGINAL EQUIPMENT MANUFACTURERS FOR THE AUTOMOTIVE INDUSTRY

11955 E. NINE MILE ROAD, VAN DYKE, MICHIGAN

T-7

About SAE Members

Continued from page 118

REBECCA HALL SPARLING, design specialist for Convair Division of General Dynamics Corp., received the 1957 Award of the Society of Women Engineers.

She directs materials research at Convair's Pomona, Calif., plant and is particularly known for her work in high temperature metallurgy, gas turbine development and nondestructive testing.

JOHN S. ADAMS has been appointed chief engineer, Bearings Co. of American Division, Lancaster, Pa. of Federal-Mogul-Bower Bearings, Inc.

Adams has been active with Bearings Co. of America Division engineering since 1948. From that time until 1953, he acted in the capacity of engineering assistant to the chief engineer. In 1953, Adams relocated in the mid-west as manager in engineering—sales. In 1956 Adams returned to Lancaster to become assistant chief engineer.

C. C. ROSS, manager, Liquid Engine Division of Aerojet-General Corp., has been appointed to the NACA Committee on Powerplants for Aircraft. In addition, Ross was reappointed as chairman of the NACA's Subcommittee on Rocket Engines.

Ross also has been appointed chairman of the Auxiliary Power Supply Task Committee by the National Security Industrial Association.

PETER C. TAPPAN has joined United Shoe Machinery Corp. as a mechanical engineer. Previously, he was with the USAF as a project engineer, Wright Air Development Center, Wright-Patterson Air Force Base.

JAMES H. ROBERTS has been made project engineer, Galion Iron Works and Mfg. Co., Galion, Ohio. Prior to joining Galion, Roberts was gear engineer, Steel Products Engineering Division, Kelsey Hayes Wheel Co., Springfield, Ohio.

ROBERT NELSON HAGARTY is now a designer with the Electric Boat Division of General Dynamics Corp. Formerly, he was a designer for Public Service Coordinated Transport.

MILFORD D. BURROWS has been made chief engineer, Bolens Products, Inc., Food Machinery and Chemical Corp. Prior to joining Bolens, he was director of engineering, the Porter-Cable Machine Co.

EDWARD SAARINEN has joined the Utica-Bend Corp. as chief test engineer—diesel. Previously, he was with Studebaker-Packard Corp. as chief test engineer.

Continued on page 125

Metallurgical, Chemical and Physical Properties

verified every hour, every heat, every day

For important engineering components in automotive, aircraft, and allied industries, ECI castings must have precise metallurgical and physical properties and dimensional tolerances in order to assure manufacturing economy and superior heat, wear, and corrosion resistance.

Control checks and tests are maintained every step of the way — "technical policemen" on sand, metals, molds, and technique. Standards on uniformity, hardnesses, time, temperature, and numerous other factors are rigidly enforced at regular, frequent periods throughout the day.

Only on this basis are we able to make and inspect more than 125,000 small, close tolerance castings per day; and to assure our customers of maximum, ultimate economy and superior performance in service.

Licensed producers of Ni-Hard, Ni-Resist, Ductile Iron, and Ductile Ni-Resist

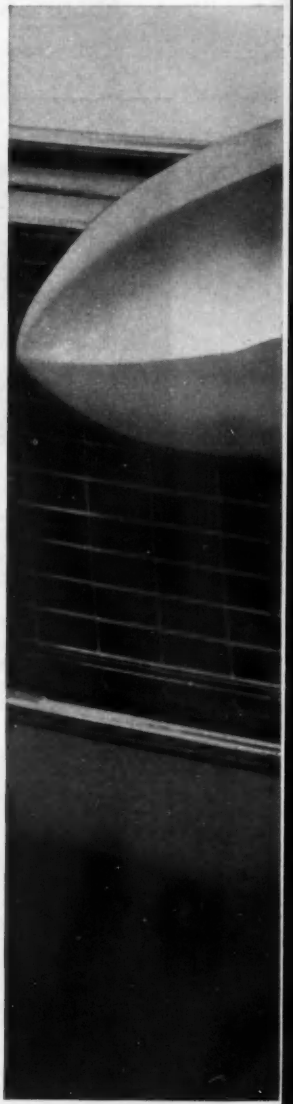
ENGINEERING CASTINGS, INC.

Marshall, Michigan

ECI

For whatever you fabricate . . .

N-A-X FINEGRAIN STEEL COMBINES STRENGTH WITH FORMABILITY



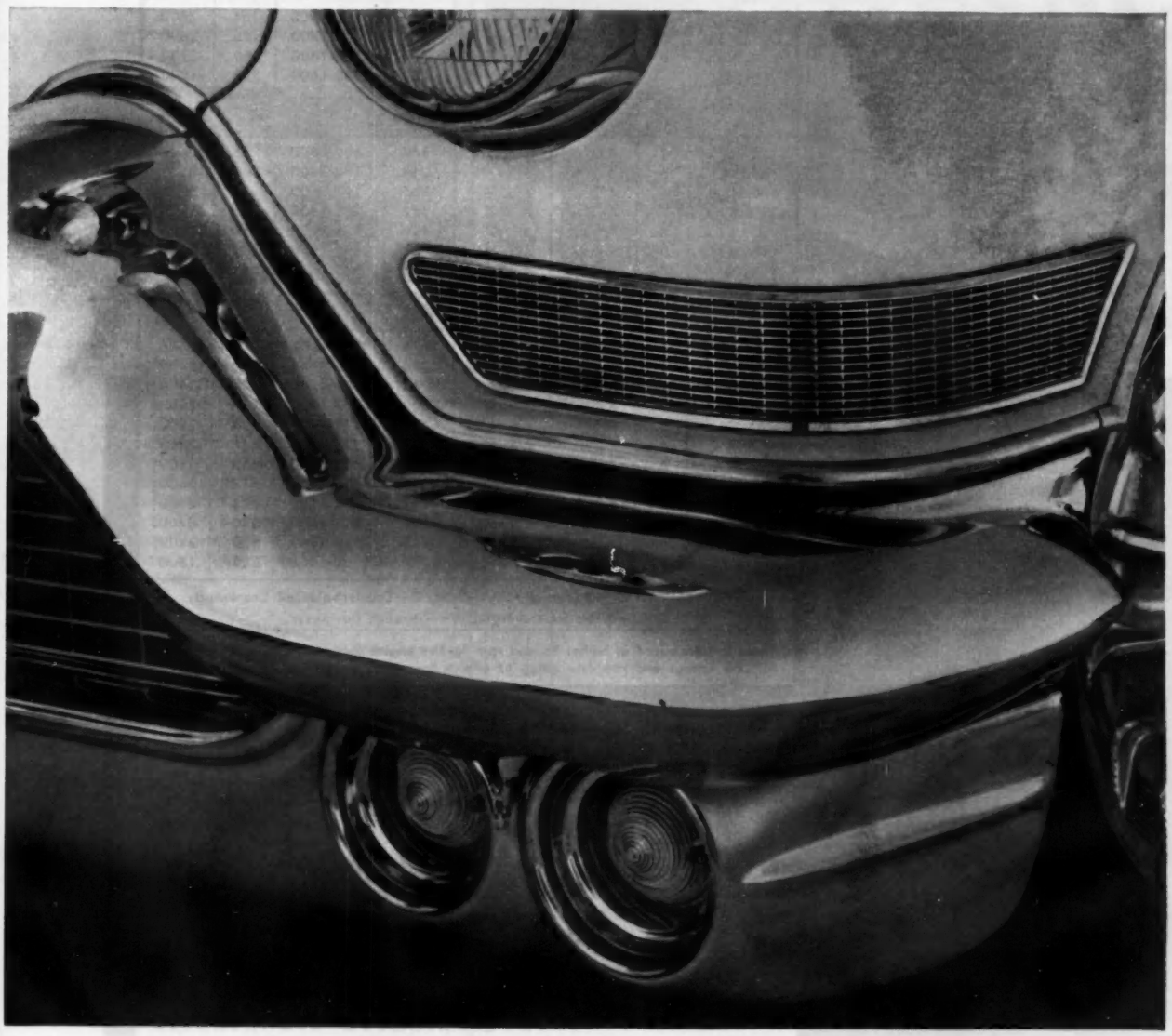
Among the many economical advantages of N-A-X FINEGRAIN—a low-alloy, high-strength steel with widely diversified applications in modern metals design—is its combination of great strength with excellent formability. Even at the higher strength levels (50% greater than mild carbon steel) N-A-X FINEGRAIN can be cold formed and drawn into difficult stampings and cold formed shapes.

Take these qualities and add the ability of N-A-X FINEGRAIN to be readily polished to a high luster at minimum cost, and when plated, you have a steel ideally suited for such applications as bumpers, bumper guards, and many others where strength and toughness with good finish is important.

Engineers and designers like N-A-X FINEGRAIN especially because its physical properties are inherent in the "as rolled" condition. No subsequent treatment is needed to insure its characteristics.

Check these other important advantages: N-A-X FINEGRAIN steel, compared with carbon steel, is 50% stronger • has high fatigue life with great toughness • is stable against aging • has greater resistance to wear and abrasion • is readily welded by any process • offers greater paint adhesion. NOTE: Where greater resistance to atmospheric corrosion is an important factor, our N-A-X HIGH-TENSILE steel is recommended.

For whatever you fabricate, from bumpers to bulldozers, with N-A-X HIGH-STRENGTH steels you can design longer life, or less weight, and economy into your products. Let us show you how.



One of many applications where N-A-X FINEGRAIN'S strength with formability saves production money.

N-A-X
HIGH-STRENGTH STEELS

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GREAT LAKES STEEL CORPORATION
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NATIONAL STEEL CORPORATION

N-A-X Alloy Div., Dept. F-4
Great Lakes Steel Corp., Detroit 29, Mich.

☐ Please send me technical data on N-A-X FINEGRAIN steel.
☐ Please have your representative contact me.

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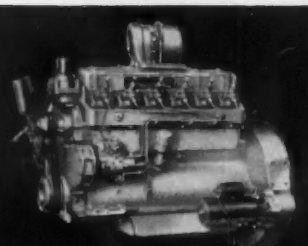
THE PAYLOAD POWER PLANT

- **fast**
- **smooth**
- **powerful**

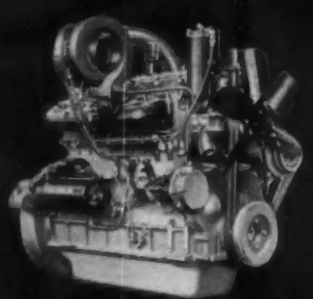
TURBO-SUPERCHARGED DIESELS							
MODEL	Cyl.	*Features	Bore and Stroke	Displ. Cu. In.	Max. Torque @ RPM	Max. HP	RPM
197-DLCS	6	ATV	4 x4	320	280-2000	131	2800
135-DKBS	6	ACTV	4¼x5	426	400-1800	185	2800
148-DKBS	6	ACTV	5¼x6	779	706-1800	280	2100
WAKDBS	6	ACTV	6¼x6½	1197	1062-1600	352	1800
NORMAL DIESELS							
180-DLC	4	AC	3½x3¾	144	102-1800	45	2400
185-DLC	6	A	3½x3¾	216	152-1200	60	2400
190-DLCA	6	AC	3¾x4	265	191-1400	85	2800
195-DLCA	6	AC	4 x4	302	221-1800	98	2800
135-DKB	6	ACV	4¼x5	426	328-1600	147	2800
148-DKB	6	ACV	5¼x6	779	584-1000	200	2100
WAKDB	6	ACV	6¼x6½	1197	845-1000	258	1800
GASOLINE							
180-GLB	4	AC	3½x3¾	144	118-1600	45	2400
185-GLB	6	A	3½x3¾	216	176-1400	67	2400
190-GLB	6	A	3¾x4	265	220-1200	77	2400
195-GKA	6	ACV	4⅛x4	320	243-1600	122	3000†
MZA	6	A	4¼x4¾	404	289-1000	128	2800†
135-GKB	6	ACV	4¼x5	426	337-1200	147	2800†
135-GZB	6	ACV	4⅜x5	451	354-1200	153	2800†
140-GKB	6	ACV	4½x5½	525	425-1000	177	2600†
140-GZB	6	ACV	4⅝x5½	554	448-1100	188	2600†
145-GKB	6	ACV	5¼x6	779	595-1000	240	2400†
145-GZB	6	ACV	5⅜x6	817	630-1100	250	2400†
WAKB	6	ACV	6¼x6½	1197	1000-1000	280	1800

***FEATURES:** A—Aluminum Alloy Pistons; C—Counterbalanced Crankshaft; T—Turbo-Supercharged; V—Vibration Dampener.

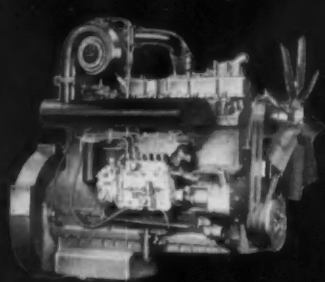
†These engines rated at higher hp and rpm for fire engine service. *Send for Bulletin 1079 for LPG ratings and complete listing of engine hp and speed ratings.*



197-DLCS—Turbocharged Diesel



135-DKBS—Turbocharged Diesel
(Also normally aspirated)



148-DKBS—Turbocharged Diesel
(Also normally aspirated)

WAUKESHA ENGINES

NORMAL and TURBOCHARGED DIESELS . . . GASOLINE . . . LP GAS
Standard or Counterbalanced Crankshafts

Truck powered by Waukesha 148-DKB Normal Diesel

Write for descriptive bulletins
WAUKESHA MOTOR COMPANY
Waukesha, Wisconsin
New York • Tulsa • Los Angeles

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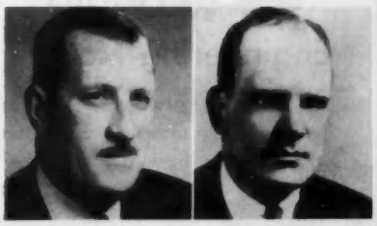
About SAE Members

Continued from page 121



Henderson Donoho

LESTER J. HENDERSON has been named vice-president in charge of sales for Republic Mfg. Co., Cleveland. Prior to joining Republic, he was vice-president and sales manager, Aviation Division, the Weatherhead Co.

Henderson was chairman of SAE Committee A-3 on Aircraft Fittings and Flexible Hose Assemblies for 14 years. He is now a member of SAE Aircraft Activity Committee and SAE Aircraft Accessories and Equipment Division.

CHARLES T. COLLINS has been named director of sales for Porsche Diesel Importers, Inc., Bridgeport, Conn. Prior to joining Porsche, he was general manager for Industrial Engine Supply Co. and Eastern Diesel Engineering Corp., West Springfield, Mass.

MYER H. WILLCHER is now production specialist, Chicago Ordnance District, U. S. Army. Previously, he was supervisory production analyst, Ordnance Stock Management Agency, U. S. Army.

Willcher is returning to the United States after serving more than ten years with U. S. Army Ordnance in the Orient.

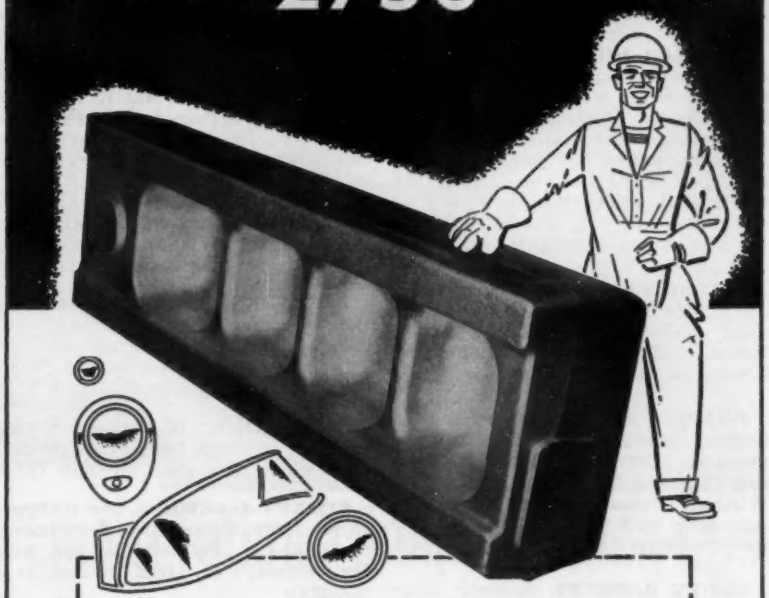
HAROLD F. WOOD, executive vice-president, Ingalls-Shepard Division, Wyman-Gordon Co., Chicago, has been elected a director of the Drop Forging Association.

BARNEY C. COX, president and general manager, Melling Forge Co., Lansing, Mich., has also been elected to the board of directors of the Drop Forge Association.

A. E. SMICK has been elected assistant vice-president, aircraft maintenance, American Airlines. Smick joined American over a year ago, and had served as director, Aircraft engineering at the maintenance and overhaul base at Tulsa, Okla. Prior to joining American, he was with Trans World Airlines.

Continued on page 126

THIS PARK CLOSED-DIE FORGING WEIGHS 2750 POUNDS



. . . and over 700 of them are helping break a glass production bottleneck

Called a "table feed rack", this steel closed-die forging was specially designed for the new glass making machinery required by the automobile industry.

Park's Complete Die-Sinking Facilities provided fast, efficient service.

And Park's Advanced Heat Treating Methods and metallurgical staff assured quality control throughout the production run.

Our sales engineers will show you how Park die-forgings can increase strength and safety — cut down size and machine time on your product requirements.

Die Forging Specialists Since 1907

THE PARK DROP FORGE CO.

773 EAST 79TH ST. • CLEVELAND 3, OHIO

CARBON, ALLOY AND STAINLESS STEEL CLOSED-DIE FORGINGS FROM 4 LBS. TO 5000 LBS.

About SAE Members

Continued from page 125

J. RALPH HOLMES, technical assistant to the general manager, product engineering section, Harrison Radiator Division, General Motors Corp., has announced his retirement.

Holmes joined Harrison in 1928 as an experimental engineer. He served as Harrison's chief engineer from 1932 until 1956 when he became technical assistant to the general manager.

WAYNE EWING, president of the Arrowhead Tool & Die Corp., Los Angeles, has been elected to the 1957–58 Board of Directors of the American Society of Tool Engineers.

CHARLES R. WIRSHING has been named metalworking chemicals sales manager, West Coast District, American Chemical Paint Co., Ambler, Pa. Wirshing became a member of the ACP sales staff in Detroit in 1947 and was transferred to Niles, Calif. in 1952.

ARDEN ROBERTS, formerly project engineer, confidential editor, has been made product engineer, confidential editor, Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc.

RALPH A. NELSON has joined the Raybestos-Manhattan, Inc., as sales engineer in the Equipment Sales Division. Formerly he was sales engineer, OEM Division, Thermoid Co., Trenton, N. J.

JOHN P. BUTTERFIELD, chief engineer in charge of Chrysler missile operations, Defense Operations Division, Chrysler Corp., has been named executive engineer in charge of all missile activities.

DUDLEY D. FULLER has received the American Society of Lubrication Engineers' National Award, which constitutes life membership in the Society for his ". . . conspicuous service to the science of lubrication . . . through research, educational leadership, and contributions to literature."

Fuller is a professor of Mechanical Engineering at Columbia University and Principle Scientist at the Franklin Institute of the State of Pennsylvania.

JOSEPH R. de MARTINO is now senior aircraft design engineer, Lockheed Aircraft Corp. Previously, he was senior project engineer, General Motors Corp.

JOHN K. ZAISER is now a designer with Anaconda Copper, Anaconda, Mich. Previously, he was a design engineer, surface controls, North American Aviation, Inc.

GEORGE MILTON SPROWLS has retired from manager of the highway transportation department, Goodyear Tire & Rubber Co., Akron, Ohio.

Sprowls started at Goodyear as experimental engineer and later became technical engineer in the highway transportation department, and subsequently manager of the department in 1928. During World War II, he served as supervisor of field investigation, U.S. Navy Rubber Survey, and later a chief consultant on rubber—Office of Defense Transportation.

Sprowls is now doing consulting work and making analyses and surveys of production, development, and financial problems in Akron, Ohio.

PARRY KELLER has retired from the Goodyear Tire & Rubber Co., Akron, Ohio. Keller served as consulting engineer, Aircraft Tire Development for the company.

BENJAMIN H. BLAIR has retired as chief engineer, leaf spring department, Eaton Mfg. Co., Cleveland, Ohio.

ROBERT J. LEWIS is now staff engineer, industrial products department, Shell Oil Co. Formerly, he was with the company's St. Louis Division as a salesman.

RAY D. STEWARD has joined the J. I. Case Co. of Churubusco, Ind. as project engineer. Formerly Steward was project engineer with American Tractor Corp., also of Churubusco, Ind.

THOMAS E. ZEERIP has been named chief engineer, ground systems support, the Martin Co., Orlando, Fla. Formerly he was director of manufacturing, Doman Helicopters Inc., Danbury, Conn. Zeerip now is in charge of design and test of ground equipment used with the missile weapons system.

REGINALD WHITSON has been named manager, management services, for the Warner Electric Brake & Clutch Co., Beloit, Wis. Formerly Whitson was western regional manager for the company.

WILLIAM EDWARD JUDY has been appointed general manager of Timken Rollenlager GmbH, Dusseldorf, Germany. Formerly he was sales engineer with Timken Roller Bearing Co., Detroit. Judy is now in charge of all operations of Timken Rollenlager and all sales operations of the Timken Roller Bearing Co. in Europe.

HERBERT GALE BRADFORD has joined General Motors Truck and Coach Division, General Motors Corp., as district sales representative. Formerly he was chief engineer and assistant general manager of the Continental Bus System, Inc. of Dallas, Texas.

Continued on page 128

Aeroquip

Engineering Notes

B. A. MAIN, JR.

With Aeroquip Detachable and Reusable ***"super gem"*** Fittings and coils of Aeroquip 666 Hose (Teflon) you can make the hose assemblies you want quickly by hand.

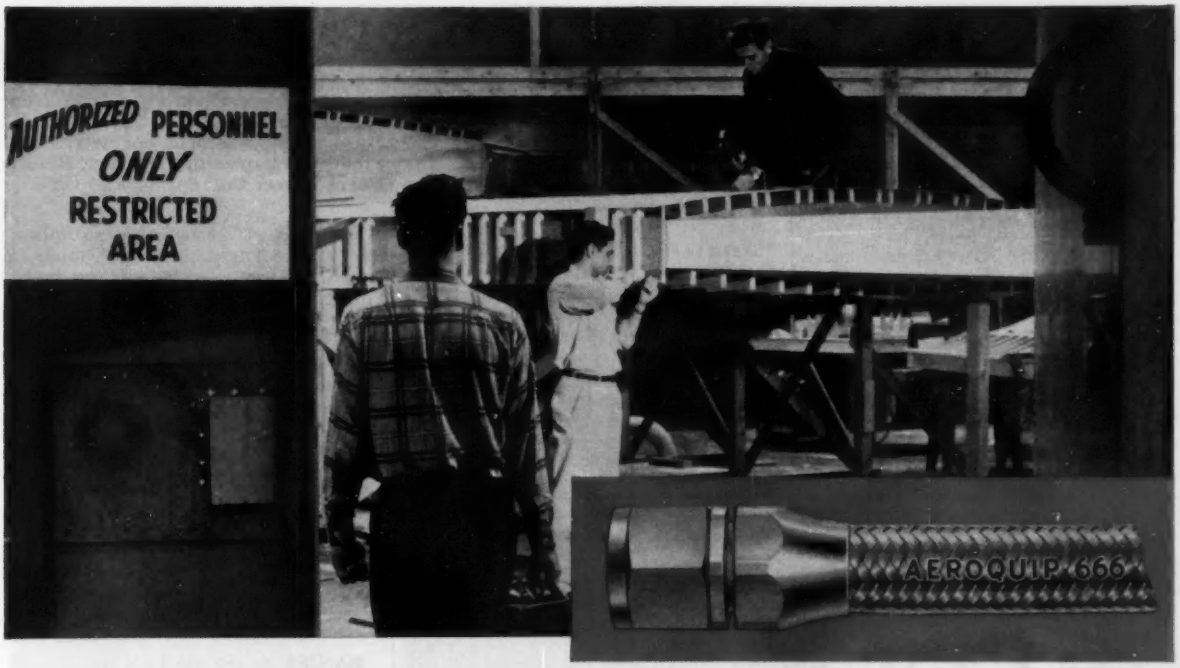
Here at Aeroquip, with simple shop equipment such as a workbench, a vise and a wrench, we make hose lines which successfully withstand all of the test requirements of the Military Specifications covering such hose lines. You can do this, too, which means you can make a hose line fit for flight service when you need it.

Not very long ago we participated in the installation of some new engines in a new high performance airplane. With coils of hose and detachable, reusable fittings, our Service Engineers and the airframe contractor's personnel were able to mock-up the installation quickly. However the work did not end here. The engine manufacturer made engineering changes on the engine which required rerouting of the hose lines and, since several changes occurred, the hose lines were reworked time and time again. This is not the end of the story. It is known that further engineering changes will be made up to and during the flight testing. This means that hose lines must be made or sometimes reworked right on the flight line.

Engineering changes mean progress and, since our detachable, reusable fittings make engineering changes easier and speedier to accomplish, we are pleased that Aeroquip Hose and Reusable Fittings are helping others make progress.

B. A. Main Jr.

VICE PRESIDENT, ENGINEERING
AEROQUIP CORPORATION



Aeroquip 666 Hose Lines (Teflon*) Simplify Mock-Ups

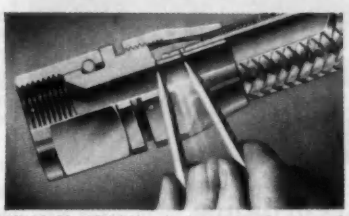
Because You Can Make The Assemblies You Want Quickly . . . By Hand

Simplify airframe, engine or accessory engineering mock-ups . . . reduce mock-up time. For high-performance fluid lines, use the *ONLY* hose lines made of Teflon that can be shortened or lengthened quickly and inexpensively . . . Aeroquip 666 Hose (Teflon) with "***super gem***" Fittings.

"***super gem***" Fittings are designed specifically for use with Aeroquip 666 Hose. They can be removed and re-attached in minutes, by hand, using bench tools. No swaging machine is needed. A small supply of Aeroquip 666 Hose and "***super gem***" Fittings allows you to make hose lines as you need them, or alter them when necessary. You never have to wait for shipments of factory-assembled lines.

Another Aeroquip advantage: "***super gem***" Fittings attach to Aeroquip 666 Hose by holding the outer wire braid, using the lip seal on the tube to hold the fluid. This means that the capacity of the fitting to hold the hose exceeds the strength of the hose itself. The "***super gem***" Fitting remains perfectly leakproof for years, as evidenced by its ability to withstand periodic proof tests when inspecting for fitness for further service. Mail coupon for complete technical information.

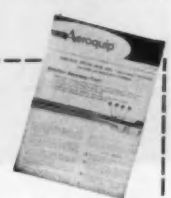
HOSE LINES OF TEFLON can be made right in your plant. A wrench, a vise and a few minutes' time are all that are needed to assemble Aeroquip 666 Hose and "***super gem***" Fittings.



UNIQUE DESIGN of Aeroquip Leakproof "***super gem***" Fitting assures three functions: (1) grips and holds the external wire braid firmly; (2) seats the inner tube without compression thus forming a lip seal; (3) positive metal-to-metal line seal.

"***super gem***" is an Aeroquip Trademark

*Du Pont tradename for its Tetrafluoroethylene resin



Aeroquip Corporation,
Jackson, Michigan

Gentlemen:

Please send me your Bulletin AEB-13 on reusable "***super gem***" Fittings and 666 Hose.

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN
AEROQUIP CORPORATION, WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 10, ONTARIO

About SAE Members

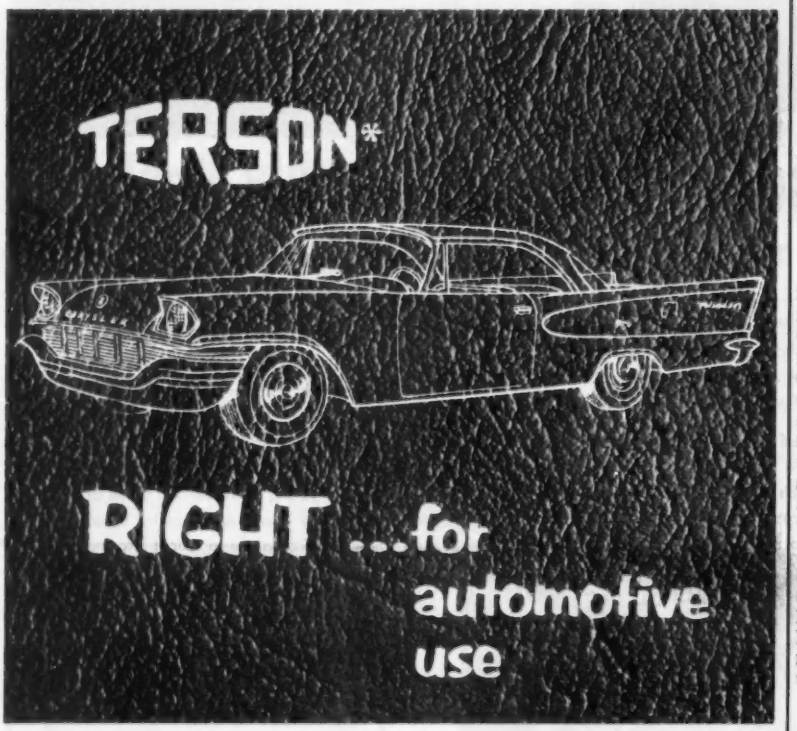
Continued from page 126

EDMOND B. COOPER has been made resident production engineer at the Dodge Truck Plant, Dodge Division, Chrysler Corp. Formerly he was managing engineer with Dodge's truck chassis project section. Cooper joined Dodge in 1943, serving in the Chicago plant, and moving to the Detroit factory in 1947 as production contact engineer.

ROBERT V. LARSON has become associated with the Caterpillar Tractor Co., Ltd. of England as assistant chief engineer at the Glasgow, Scotland plant. Prior to this post, Larson was staff engineer—research, Caterpillar Tractor Co., Peoria, Ill.

WILLIAM C. LARSON is now a staff member of the Sandia Corp., Albuquerque, N. Mex. Prior to joining Sandia, he was a project engineer with Holley Carburetor Co.

ROBERT W. LOTZ, formerly supervisor, quality control, Engine Division, Chrysler Corp., has become project engineer of the division.



Consistent Production in Accordance with your Exact Specifications

Rigid quality controls assure uniformity of every shipment. This, plus Athol's many years of experience and continuous research in the coated fabric field, spells out the reason why this skilled producer is being specified by more and more large users in the automotive industry. Inquiries invited.

VINYL FABRICS FOR AUTOMOTIVE USE

Strategically located plants at Butner, N. C. and Athol, Mass.

ATHOL MANUFACTURING COMPANY

*Reg. U. S. Pat. Off. NEW YORK • ATHOL, MASS. • CHICAGO

JAMES H. ROBERTS has been named project engineer, Galion Iron Works and Mfg. Co., Galion, Ohio. Formerly he was gear engineer, Steel Products Engineering Division, Kelsey Hayes Wheel Co., Springfield, Ohio.

NATHAN N. SHIOVITZ has joined Rocketdyne Division, North American Aviation, Inc., as design engineer. Formerly he was product design engineer, Engineering Staff, Ford Motor Co.

HAROLD C. GLIDEWELL has become chief draftsman, Peterbilt Motors Co., Oakland, Calif. Prior to this post, he served as maintenance superintendent, East St. Louis City Lines, St. Louis, Ill.

Glidewell served as SAE vice-president for Transportation and Maintenance from 1950 until 1953. He has been active in the St. Louis Section as secretary in 1953-54 and chairman in 1954-55.

DANIEL E. HAMILTON has retired from the Department of the Army, Ordnance Tank Automotive Center, Detroit. He served as automotive maintenance engineering specialist.

RAYMOND L. MATTSON, formerly in the engineering mechanical department, General Motors Research Staff, General Motors Corp., has now been made assistant department head, General Motors Research Staff.

Mattson is a past-chairman of the SAE Iron and Steel Technical Committee. He is now a member of the Steering Committee, Division IV, Residual Stresses, also of the Iron and Steel Technical Committee.

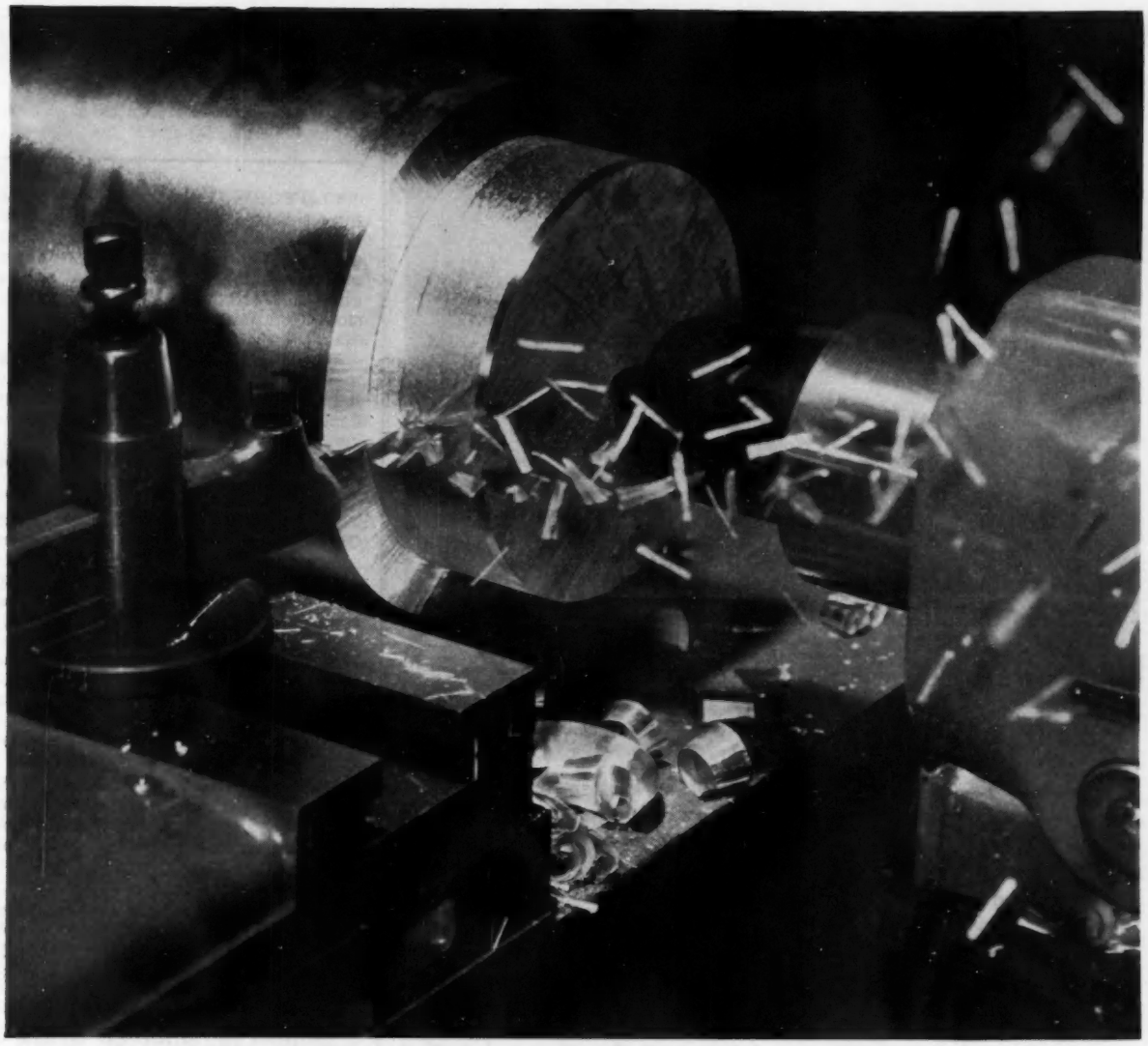
EDWARD GEORGE GRINHAM has been made consulting engineer for Standard Motor Co., Ltd., and Dunlop Rubber Co., Ltd., Warwickshire, England. Formerly, Grinham was deputy managing director and technical director for the Standard Motor Co., Ltd.

CHARLES L. WATERHOUSE has been named liaison engineer, foreign operations, foreign products engineering department, Enginering Staff, Ford Motor Co. Previously he has served as manager, styling special products, Engineering Division and also in engineering capacities with the Mercury Division of Ford.

Waterhouse served as SAE vice-president for Body Activity in 1954 and 1955.

C. D. FLANIGEN has formed his own engineering consultant firm which will cover engineering and marketing on aircraft equipment. Previously, he was general manager of Marotta Valve Corp., Boonton, N. J.

Continued on page 130



Speed! Of all structural metals, Magnesium costs less to machine

In the picture above, a lathe is making a roughing cut of 0.800" in an eight inch magnesium billet. The feed is 0.030 inches per revolution at a speed of 630 feet per minute. In finishing operations, cuts of 0.500" can be made with a feed of 0.003 ipr and a speed of 5,000 fpm.

That's real speed and efficiency—the kind you can always expect when you machine magnesium. This remarkable metal can be milled, drilled, sawed, reamed, bored, planed, tapped and threaded faster than any other structural metal!

Faster machining means easier machining and lower cost machining. It means more production per hour and per dollar, and longer tool life.

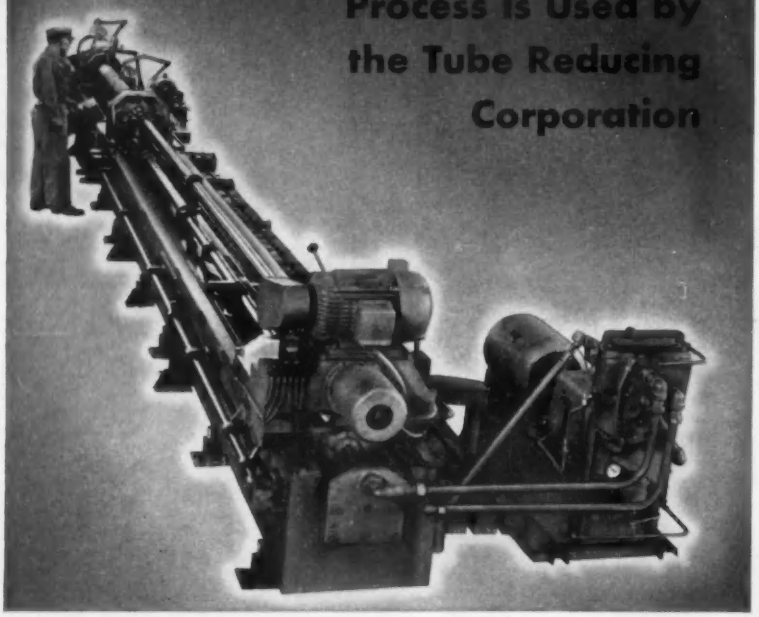
The following table shows how well magnesium compares to the others:

METAL	RELATIVE MACHINABILITY
magnesium	1.0
cast aluminum	1.8
brass	2.3
cast iron	3.5
rolled aluminum	5.0
mild steel	6.5

Let us give you more information about the machinability of magnesium. Contact the nearest Dow sales office or write to THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan, Dept. MA 1404D.

YOU CAN DEPEND ON DOW

Why MICROHONING Process is Used by the Tube Reducing Corporation



The carbon steel, stainless steel, alloy steel and non-ferrous tubes manufactured by the Tube Reducing Corporation are used on applications that require high strength, uniform wall thickness and surfaces free of pits, scratches or other imperfections.

In processing its tubes, Tube Reducing uses Microhoning, either to prepare the tubing for its exclusive "Rockrite" process, or to generate functional characteristics in finished tubing.

As a preparatory operation—which produces a round, straight bore and a clean-cut, cross-hatch surface pattern—Microhoning helps to improve the results of "Rockriting." The Microhoned surface slides easily over the "rocking" mandrel and compresses to a smooth, flaw-free surface that passes the most rigid inspection and tests.

Other "Rockrite" tubes, used in such applications as hydraulic cylinders, are Microhoned after "rocking" to generate final bore size and geometric accuracy.

The principles and application of Microhoning are explained in a 30-minute, 16mm, sound movie, "Progress in Precision"... available at your request.

☐ Please send me "Progress in Precision" in time for showing on _____ (date).
☐ Please have a Micromatic Field Engineer call.
☐ Please send Microhoning literature and case histories.

NAME _____

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COMPANY _____

STREET _____

CITY _____ ZONE _____ STATE _____

MICROMATIC HONE CORP.
8100 SCHOOLCRAFT AVENUE · DETROIT 38, MICHIGAN

About SAE Members

Continued on page 128

CLIFFORD O. SCHAEFFER has joined the J. I. Case Co.'s Tractor Works as assistant chief experimental engineer. Previously, he was senior project engineer, experimental stress analysis, Tractor and Implement Division, Ford Motor Co.

W. A. KINNAMAN has been made manager, product planning, for the light military electronic equipment department, General Electric Co. Previously Kinnaman was manager, product planning, of the aircraft products department for the company.

W. R. HUTCHINS has joined the General Tire & Rubber Co. as sales representative of the Industrial Products Division. Previously he was sales representative, Hondaille Industries, Inc., Detroit, Mich.

GLENN A. EVANS has become general manager of the St. Joseph Division, Whirlpool-Seeger Corp. Prior to his new post, Evans was general manager, Marion Division of the company.

PATRICK WAYLAND BAKER, formerly a test and development engineer with Chrysler Corp., has been appointed a senior engineer for the company.

ROBERT L. WILKINSON has been named manager for export sales, Taylor Forge and Pipe Works, Cicero, Ill. He had been with Sinclair Refining Co. as a sales engineering supervisor.

GEORGE A. SCHAUER is now a project engineer with Sundstrand Aviation Division, Sundstrand Machine Tool Co. Formerly, he was a design engineer, Marine Equipment Co., Houston, Tex.

GUY FOX has been named Eastern Sales Manager, Standard-Triumph Motor Co., Inc., New York City. Formerly Fox was general manager, South Eastern Motors, Inc., Hollywood, Fla.

WILLIAM R. HANEY, JR. is now an associate engineer with the Santa Monica Division, Douglas Aircraft Inc. He had been with Ford Motor Co. as a development engineer.

HOMER H. RHOADS has resigned as president of Hydro-Aire, Inc., to establish his own business of Aircraft Corporate Financing and Consolidations. Rhoads established and headed Hydro-Aire, Inc. for 15 years.

He will now deal principally with the accessory and electronic companies merging with the larger airframe and engine companies.

KEITH PETTIGREW has joined the Toowoomba Foundry Pty. Ltd. of Queensland, Australia, as engineering draftsman. Prior to his new post, Pettigrew was junior engineer at General Motors of Canada, Ltd., Ontario, Canada.

ADAM K. STRICKER, JR. has started the Stricker & Henning Research Association, Inc., and will serve as the president. His business will be located in New York City and serve in professional engineering and management consulting. Formerly he was on the business research staff of General Motors Corp.

JOHN J. NOPPER, formerly manager, aviation department, AP Parts Corp., has joined the sales promotion department, Champion Spark Plug Co.

HERBERT CALDWELL, currently manufacturing manager, Lockheed Aircraft Corp., has been assigned to the new position of assistant general manager at Lockheed.

CHARLES S. WAGNER, formerly production manager, has been named manufacturing manager, Lockheed.

HAROLD M. HARRISON has been made chief systems development engineer for Lockheed. Formerly he was master scheduling manager.

THERON B. FINLAY, formerly sales engineer in the Toronto Division, Linde Co., division of Union Carbide Canada, Ltd., has been made sales engineer for the division in Columbia, Canada.

GORDON E. WHELPLEY has joined Ingersoll-Rand Co., Painted Post, N.Y. as design engineer in the valve and regulation department. Formerly he was with Corning Glass Works in the mechanical engineering department.

JAMES L. HAGENER has been made senior engineer, suspension structure, Ford Motor Co. Prior to this post he was project engineer for Ford.

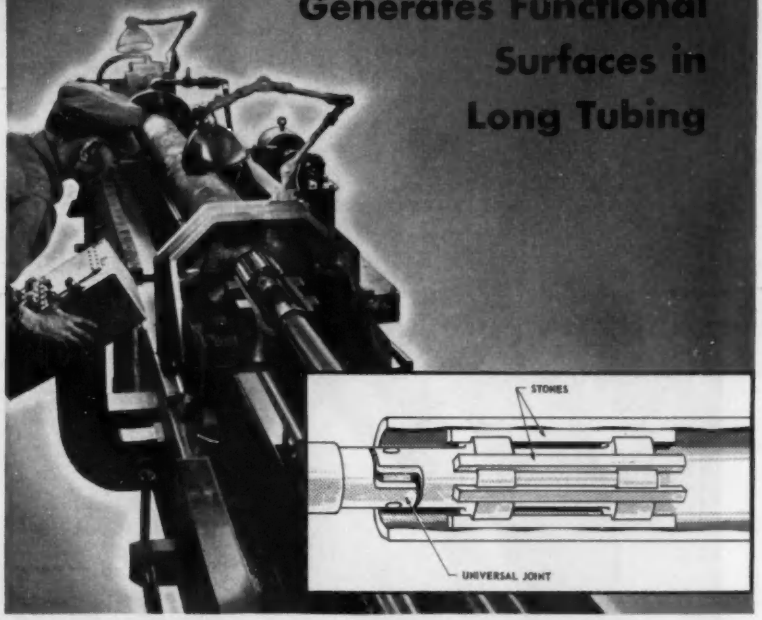
CHESTER JENNINGS BRIAN, JR. has joined Pesco Products Division, Borg-Warner Corp. as development engineer. Formerly, he was rocket test engineer, Bell Aircraft Co.

ROBERT J. BROWNE has been named general manager and chief engineer for Philadelphia Pump and Machinery Co. Previously, he was design and development engineer for Eaton Mfg. Co.

CHARLES E. BLAKESLEE has been named manager, field technical service, Lincoln Division, Ford Motor Co. Prior to joining the Lincoln Division, he had been field service engineer, Mercury Division, at Ford.

THOMAS H. AAL has joined Fairchild Engine Division, Fairchild Engine and Airplane Corp., as a field engineer. Formerly he was a project engineer with the Department of the Air Force.

How MICROHONING Generates Functional Surfaces in Long Tubing



Microhoning is used by the Tube Reducing Corporation in processing many types of tubing that range up to 18 feet long and 9½ inches in diameter. The tubes are Microhoned on a horizontal Hydrohoner equipped with a hydraulic clamping fixture that is easily adjusted to handle tubes of various sizes.

Microhoning tools have long abrasive sticks which cannot follow irregularities in the bore. The abrasive action removes high spots while generating required surface characteristics and accurate geometry. A universal joint, connecting the tool body to the drive shaft, eliminates any tendency of abrasive action to change the bore location.

Typical processing of "Rockrite" tubes: To remove scale and deep scratches . . . hot rolled, pierced billets are first bored. Then, the bores are Microhoned—stock removal rate is .015 inch from a 4½-inch diameter x 128-inch length in less than 30 minutes. The Microhoning operation generates accurate, round, straight surfaces with the required finishes of 20 to 30 microinches r. m. s.

Send coupon for complete information.

Learn how Microhoning will give efficient stock removal, closer tolerances, accurate alignment and functional surfaces.

☐ Please have a Micromatic Field Engineer call.
☐ Please send Micromatic literature and case histories.

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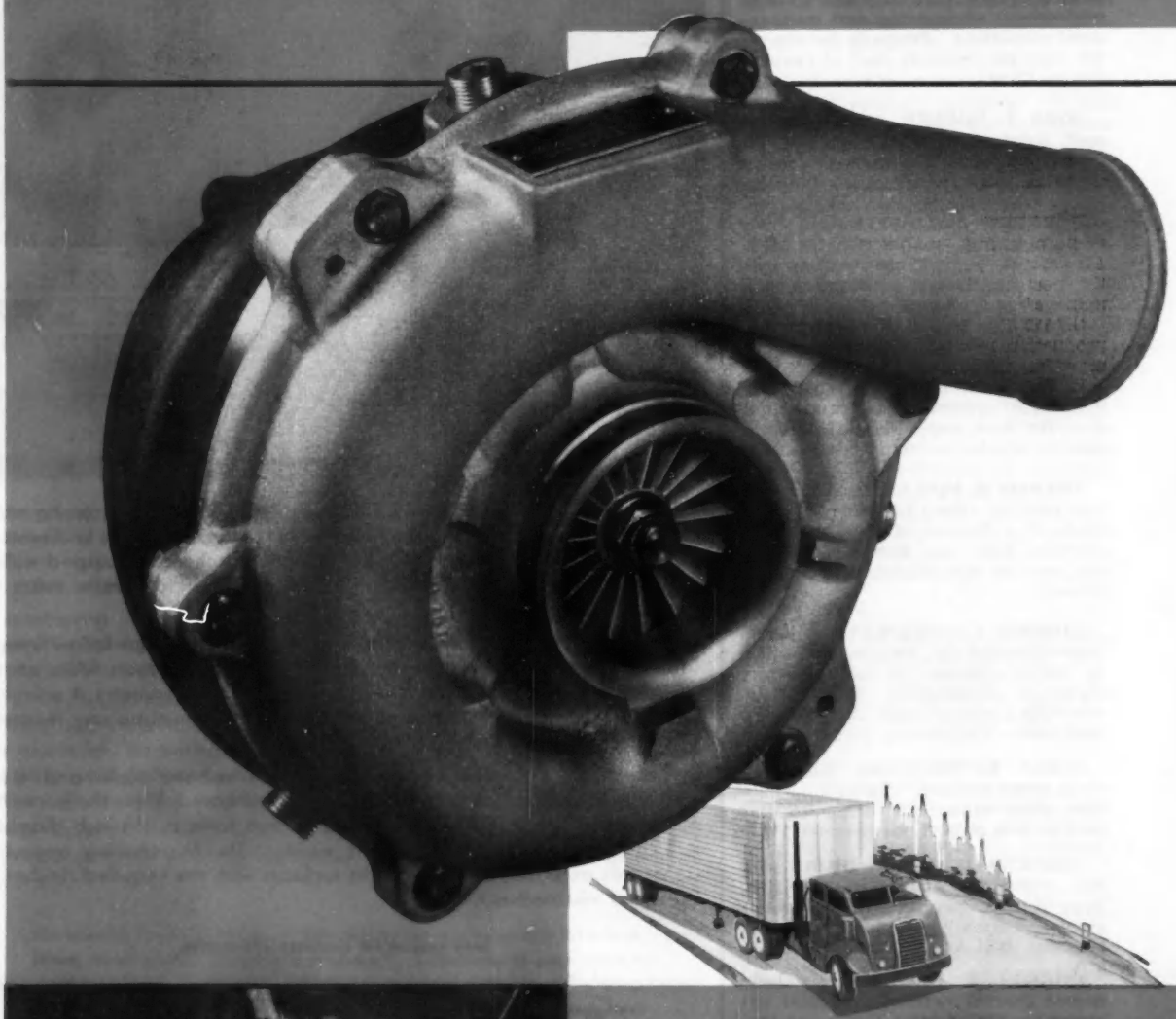
Out of Thompson's



Simulated service-condition lab test of Thompson Turbocharger to determine capacity under varied loads and temperatures.

Aerodynamics Laboratory...

NEW THOMPSON TURBOCHARGER

simpler design, easier to service, longer life

New Thompson Turbocharger for diesel engines up to 500 horsepower combines maximum supercharging effect with a simple rotor design. Problems encountered on other superchargers with oversize shafts, split bearings, and complex diffusers are eliminated on the Thompson Turbocharger.

This new design of supercharger turns at lower speed, yet provides ample compression to meet your supercharging requirements.

For over a half-century, Thompson has been a leading designer and producer of automotive parts. This experience has been combined with our leadership in aerodynamic engineering, to produce the most efficient and simplest design of turbocharger now available for automotive-type diesel engines.

Several sizes of Thompson Turbochargers are available to supply air augmentation for diesel engines up to 500 horsepower. Engineers from the Jet Division will be glad to work with you in providing a Thompson Turbocharger for your present engine design.

This data booklet SJ-157 contains information to help you equip your engines with Thompson Turbochargers. Write for it on your company letterhead.

JET DIVISION

Thompson Products, Inc.

CLEVELAND 17, OHIO

It pays to equip your trucks with the Air Brakes America's Leading Fleet Operators prefer—

BENDIX-WESTINGHOUSE

"DURING OUR 88 YEARS IN BUSINESS

We've bought 350 trucks—and when it comes to Air Brakes, we prefer BENDIX-WESTINGHOUSE!"

MR. OLIVER G. WETTERAU, *Vice-President*
Wetterau Grocer Company, Inc.

From general headquarters in St. Louis, Missouri, Mr. Wetterau helps direct the activities of a vast wholesale grocery firm serving I. G. A. stores in central and eastern Missouri. Last year the company's fleet of 200 vehicles rolled up a total of 2,000,000 miles while delivering over $50,000,000 worth of dry groceries, meats, produce and frozen foods. "In distributing foods in this volume," says Mr. Wetterau, "low cost and close timing in every phase of operation are of paramount importance. Our Bendix-Westinghouse Air Brake equipment measures up in every detail." Wetterau Grocer Company operates three distributing centers and employs 425 people.

"In our 23 years of business

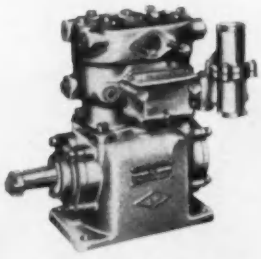
We've bought 1,150 trucks—and when it comes to Air Brakes, we prefer BENDIX-WESTINGHOUSE!"

MR. ARNOLD CASSENS, Secretary and Operations Manager, Cassens Transport Company

From general headquarters in Edwardsville, Illinois, Mr. Cassens helps direct the activities of a firm serving points in the Midwest and the West Coast. In 1955 Cassens Transport rigs rolled up a total of over 8,000,000 miles while hauling automobiles from Detroit, Michigan, to Illinois, Missouri, Kentucky, Iowa, California, Washington and Oregon. The company employs over 200 people and maintains terminals in Michigan, Indiana and Illinois.

It is a rarity, indeed, when a product in any field demonstrates customer preference so strong that it continually *outsells all other competition combined* year after year. Yet, for the past twenty-seven years, this has been the remarkable accomplishment of Bendix-Westinghouse Air Brakes in the truck and bus fields! In fact, recognition of the greater safety, economy and dependability of Bendix-Westinghouse Air Brakes by truck buyers has resulted in their factory installation on more and more truck models of all sizes.

Chances are good that your trucks, too, offer the many advantages of these powerful brakes. If not, we suggest you take advantage of the proven preference and superiority of Bendix-Westinghouse Air Brakes by offering them as factory-installed equipment. It's one sure and easy way to add more sales-appeal to your vehicles!



Over 2,000,000 compressors produced over a twenty-seven-year span stand behind the TU-FLO 400. Many advanced features guarantee performance no other compressor can equal.

Bendix-Westinghouse AIR BRAKES

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE COMPANY • General offices and factory—Elyria, Ohio. • Branches—Berkeley, Calif., and Oklahoma City, Okla.

Obituaries

JOSEPH B. ARMITAGE

Joseph B. Armitage, vice-president and consultant for Kearney and Trecker Corp., Milwaukee, and SAE vice-president for Production Activity in 1948, died in May.

Armitage had been with Kearney and Trecker since 1921, having joined the company as chief engineer. He was made vice-president in charge of engineering in 1944 and in 1956 was named consultant for the firm.

Armitage was born in Hyde, Cheshire, England, in 1881 and began in industry in 1896 as an apprenticed draftsman with Narragansett Machine Co. in Providence, R. I. He joined Browne and Sharp Mfg. Co. in Providence as a draftsman in 1900.

From 1904 to 1905, he attended Rhode Island State College where he completed a special mechanical course and subsequently returned to Brown and Sharpe as a designer on special machinery and milling machines.

Armitage became a linotype machinery designer for Electric Compositor Co. in Woonsocket, R. I. in 1907 and two years later rejoined Brown and Sharpe as a machinery designer.

From 1910 to 1918, Armitage was chief engineer in charge of engineering and drafting at Narragansett Machine Co. He then became a mechanical engineer in the research laboratories of Aluminum Castings Co. in Cleveland, the position he held prior to joining Kearney and Trecker.

WALTER GROTHE

Walter Grothe, member of SAE since 1917, died March 17.

Grothe was born in 1877 in Chicago. In 1917 Grothe joined the C. L. Best Tractor Co. in San Leandro, Calif. as mechanical engineer in charge of heat treating. He served with the company until 1927 when he joined the Caterpillar Tractor Co. He started as engineer in charge of steel treating and subsequently was named assistant to the vice-president, Research Division of Caterpillar. He remained in this capacity until retirement in 1947.

Grothe founded the metallurgical system for Caterpillar and developed the techniques which were so necessary to the tractor business in achieving superior steels and fatigue resisting materials. His work is a monument to the success of Caterpillar.

Continued on page 137

devoted to Research
GYRO ASSEMBLY AND TEST

Mechanical and Electrical Engineers, with a personal interest in precision mechanisms, where a high degree of accuracy is required, and a pride in the precision of the product they help build, we offer truly challenging opportunities.

You will do development work and testing in one of the country's most versatile laboratories, working with the top men in the field and the finest test, research and development equipment. As a part of our Major, Permanent, Expansion Program, new plant facilities are being added in suburban Milwaukee.

AC provides financial assistance toward your Master's Degree. Graduate program also available evenings at Univ. Wisconsin, Milwaukee. GM's aggressive position in the field of manufacture and GM's policy of decentralization creates individual opportunity and recognition for each Engineer hired.

RECENT EE, ME GRADUATE
INQUIRIES ALSO INVITED

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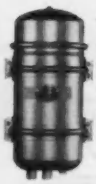
To arrange personal, confidential interview in your locality send full facts about yourself to

Cecil E. Sundeen, Supervisor of Technical Employment
THE ELECTRONICS DIVISION
GENERAL MOTORS Corporation
FLINT 2, MICH. MILWAUKEE 2, WIS.

THERE'S NO SUBSTITUTE
for LUBER-FINER'S
ENGINEERED
PROTECTION

YES! IT'S WHAT'S
INSIDE
THAT COUNTS
The Efficiency of Luber-finer's Exclusive Patented Process
HAS NEVER
BEEN EQUALLED!

USE ONLY GENUINE
Luber-finer
DIESELPAKS



Only a Luber-finer Unit *Plus* a Genuine Luber-finer Pack can give the Exclusive Patented Filtering Process that has made Luber-finer The Standard of The Industry Since 1936!!

THERE'S A LUBER-FINER MODEL FOR EVERY TYPE OF ENGINE— EVERY TYPE OF OIL!!

LUBER-FINER PACKS AVAILABLE

1. REFINING PACK
Introduced to the public in 1935 for use with straight mineral oils, fuel oils, hydraulic oils, and inhibited industrial oils.

2. DIESELPAK
First made available in 1941, the DIESELPAK was primarily designed for use with H.D. detergent compounded oils and has also achieved outstanding results when used with fuel oils and straight mineral oils.

DON'T BE MISLED BY PRICE ALONE!

There is no substitute for DIESELPAK'S Patented Filtering Process for H.D. Compounded oils AT ANY PRICE!

The DIESELPAK cleans more oil faster —keeps it CLEAN longer—and gives more service and better engineered protection than ANY of the substitute filtering elements being offered for Luber-finer units.

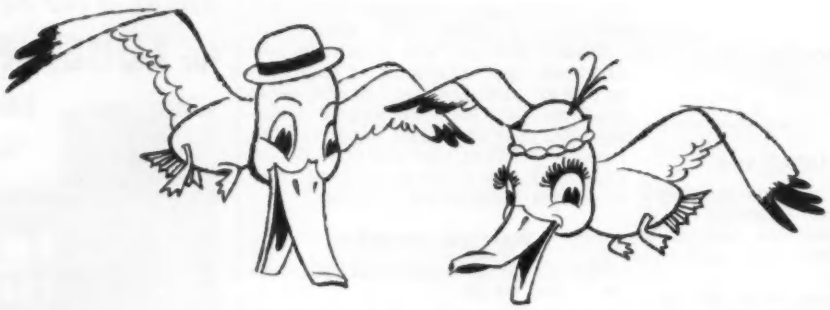
IT PAYS TO GET THE BEST!

STANDARD OF THE INDUSTRY SINCE 1936

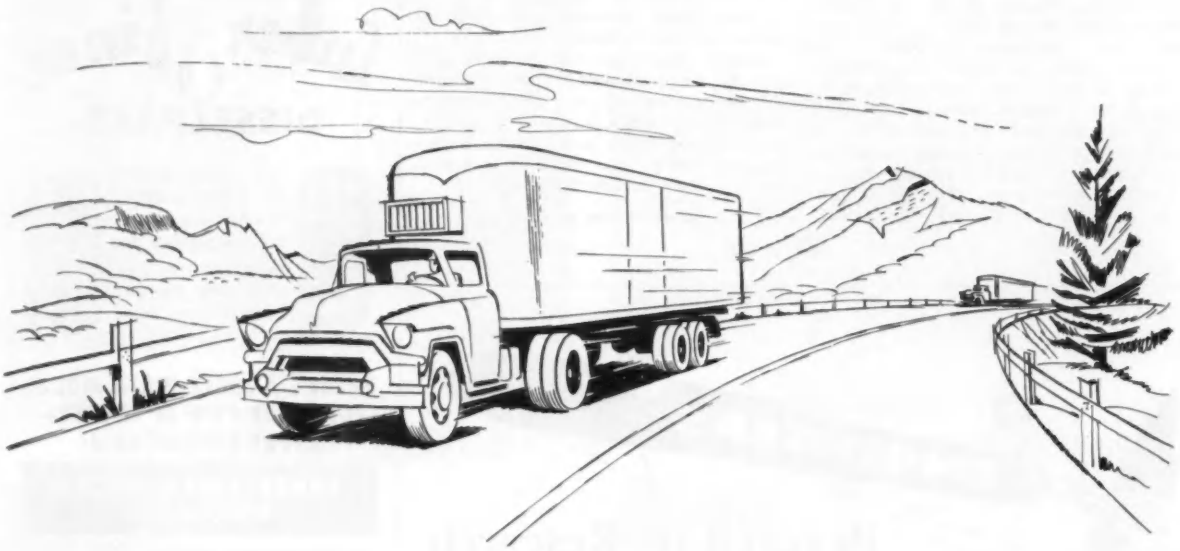
Luber-finer Units are Standard and Optional Equipment on America's Leading Diesel Trucks, Tractors, Stationary Engines.

Write for Complete Information to Dept. 502

LUBER-FINER, INC.
2514 S. Grand Ave., Los Angeles 7



They are also birds of a feather ...all have SKF® bearings



By flocking to a single source where all basic types of bearings are available, many in the automotive industry are fast becoming "birds of a feather."

They share a common knowledge that **SKF**'s complete line provides a bearing with *plus values* for every application.

Why not profit by their experience, and wing your way towards **SKF**, today. 7732

SKF

EVERY TYPE—EVERY USE

- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings* ("Tyson")

® Reg. U.S. Pat. Off. Tyson Bearing Corporation

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

Obituaries

Continued from page 135

HUBERT HOLLMANN

Hubert Hollmann, executive engineer of Brad Foote Gear Works, Inc., Chicago, died May 22.

Hollmann was born in Romania and came to the U.S. in 1921. He had been a member of SAE since 1944. Before joining Brad Foote Gear Works, Hollmann was employed by the Cleveland, Ohio, Trencher Co., and the Buckeye Traction Ditcher Co., Findlay, Ohio.

He held numerous patents and was noted for his development, during World War II, of the planetary gear used by the British Government in their Mark II tank.

JERRY D. HESTER

Jerry D. Hester, vice-president, customer relations, Paul Omohundro Co., Paramount, Calif., has died.

Hester was born in 1918 and became a member of SAE in 1955. From 1942 until 1953 he served with Northrop Aircraft, Inc., as supervisor in the Aircraft Engineering Division. In 1953 he joined the Paul Omohundro Co. as director of manufacturing control. He subsequently was made vice-president, customer relations.

ALFRED C. GUNSAULUS

Alfred C. Gunsaulus, member of SAE since 1943, died April 4.

Gunsaulus was born in 1892 and worked in various engineering capacities from 1915 until 1922 when he joined Goodyear Tire & Rubber Co. He served with them as development engineer until 1942 when he joined Goodyear Aircraft Corp.

Gunsaulus had served as manager, development engineering department, Wheel and Brake Division, since 1944.

JOHN F. SCHOTT

John F. Schott, development manager of footwear and general products, U. S. Rubber Co., Mishawaka, Ind., died on April 4.

Schott was born in 1896 and joined U. S. Rubber Co. in 1917. He served as textile engineer and subsequently was made development manager. He had been a member of SAE since 1956.

NEIL McEWEN

Neil McEwen, member of SAE since 1952, died on Jan. 13.

McEwen was born in 1889 and had been employed at the Krug Baking Co., Jamaica, N. Y. He served with them as director of transportation, joining the company in 1917.

HAROLD ROSEN

Harold Rosen, general manager of the American Grease Stick Co., Muskegon, Mich., died April 14.

Rosen was born in 1892 and in 1919 organized the firm of Rosen Brothers, builders and contractors. He served as active head, and also head of Consumers Tire Stores, Inc., which he also organized in 1923. In 1931 Rosen organized the American Grease Stick Co. for the development and sale of "Door-Ease," a solidified lubricant which he invented. He had been general manager of the company for 25 years.

Rosen was an active member in SAE since joining in 1935. He served as secretary, treasurer and chairman of the SAE Muskegon Group as well as chairman of Membership Committee and member of the governing board, SAE Western Michigan Section.

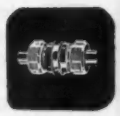
Continued on page 139

ROCKFORD

CLUTCH PORTS HELP HEAT & DIRT ESCAPE

Small Spring Loaded

Heavy Duty Spring Loaded


Oil or Dry Multiple Disc

Heavy Duty Over Center

Power Take-Offs

Speed Reducers

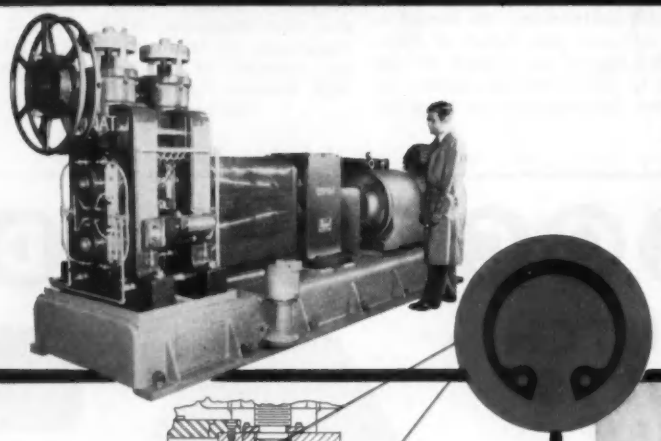
Nine large ports in the sides and twenty-one holes in the top of this ROCKFORD Spring-Loaded CLUTCH cover provide increased ventilation during operation under adverse conditions. Extreme heat, generated by modern high-speed engines, is dissipated—to prevent burning and warping. Dirt, grease and moisture, encountered in off-highway operations, are carried away—to avoid excessive clutch wear.

BW SEND FOR THIS HANDY BULLETIN
Gives dimensions, capacity tables and complete specifications. Suggests typical applications.

ROCKFORD Clutch Division BORG-WARNER
316 Catherine St., Rockford, Ill., U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

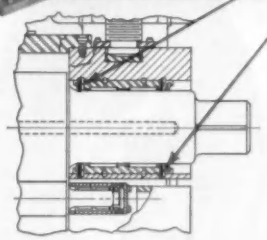
CLUTCHES

7-inch Waldes Truarc retaining rings cut costs, speed assembly-disassembly of 2-high/4-high mill

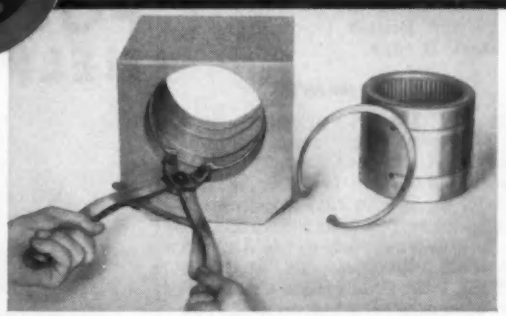


New Model TA-625 2-high/4-high combination rolling mill designed by Stanat Manufacturing Co., Long Island City, N. Y., reduces 2½" ingot to precision-rolled strip as thin as .001".

Waldes Truarc retaining rings help make possible a complete change of work rolls in 20 minutes...solve difficult problems of accuracy control by achieving positive location of bearings to extremely close tolerances. Rings eliminate costly parts and machining, save space, reduce maintenance.



In the assembly illustrated above, 7" Waldes Truarc (Series 5000) retaining rings—three on each roller—are used to position heavy-duty needle bearings in the bearing housing. Smaller rings position bearings in other roller assemblies and retain the shaft of a dual handwheel screwdown. All in all, 18 Waldes Truarc rings are used in the mill. They replace machined shoulders, spacers and lock nuts...eliminate costly threading, other machining operations.



Assembly is simple, even with giant 7" diameter Truarc ring. Special Truarc ratchet pliers grasp the ring securely, ease it into the groove, snap it securely into position. Smaller pliers and various high-speed assembly jigs are available for other rings, permit assembly-disassembly to be performed rapidly even by unskilled labor.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product...to save you material, machining and labor costs. Quick and easy to assemble and disassemble, they do a better job of holding parts together. Truarc rings are precision-engineered and precision-made, quality controlled from raw material to finished ring.

36 functionally different types...as many as 97 different sizes within a type...5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U.S.A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!

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TRUARC®
RETAINING RINGS

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Company .....
Business Address .....
City ..... *Zone* ..... *State* .....

SAO79

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

Obituaries

Continued from page 137

J. HENRY REISNER

J. Henry Reisner, eastern sales representative for Aeroquip Corp., died March 31. He had been an active member of SAE since 1928.

Reisner was born in 1905 and in 1924 became a partner in the Reisner Aero Service, Hagerstown, Md. In 1926, with associates, he formed the Kreider Reisner Aircraft Co. This company built and produced the C-2 Challenger biplane before selling the company to the Fairchild Engine and Aircraft Co. in 1929. Reisner and his brother attained distinction for designing and building the first cantilever, single-spar, low wing monoplane ever produced in the U. S. With it they won the Scientific American Aerial Trophy and top honors in the 1926 aerial races at the Philadelphia Sesquicentennial.

After the sale of the company to Fairchild, Reisner continued as manager until 1938. He became associated with Aeroquip in 1940.

WILLIAM PHILLIP COURT

William P. Court, president and general manager of the Court Radiator Plant Ltd., Ontario, Canada, died in September, 1956.

Court was born in 1889 and began his career by opening a welding shop in Ontario. The business expanded and in 1930 was incorporated under its present name.

He had been a member of SAE since 1948.

GLEN ALLEN SPRAKER

Glen Allen Spraker, member of SAE since 1943, died Nov. 3.

Spraker was born in 1890 in Kokomo, Ind. He worked, from 1913 to 1931 in various purchasing and expediting capacities before becoming district sales representative for McInerney Spring & Wire Co., Grand Rapids Metalcraft Corp., and Detroit Moulding Co. In 1935 he became sales representative for Detroit Gasket & Mfg. Co., Toledo Industrial Rubber Co., Mouldings, Inc., and Precision Spring Corp.

In 1947 he was Wisconsin and Minnesota representative for the companies, and from 1948 to 1957 restricted his activities largely to Detroit Gasket & Mfg. Co. and Mouldings, Inc.

E. C. GARLAND

E. C. Garland, member of SAE since 1925, died recently.

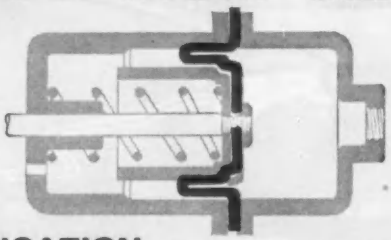
Garland was born in 1883 and started working for the Cadillac Motor Car Co., Detroit, Mich. in 1915. He served with them as technical manager until retirement.

Continued on page 141

NEW... PERFORMANCE CERTIFIED

BELLOFRAM®

DIAPHRAGM SEALS



√ **CERTIFICATION** — The BELLOFRAM CORPORATION will now give every last one of your BELLOFRAM Diaphragm Seals unconditional job performance CERTIFICATION, provided seal materials used are in accordance with the recommendations of BELLOFRAM's own engineers. *This new policy is a radical deviation from the usual, no-guarantee practices found throughout the rubber molding industry.*

√ **REQUIREMENTS** — If you give BELLOFRAM complete seal function data such as fluids in contact, minimum and maximum operating pressure, proof pressure, burst pressure, operating temperature, temperature time factors, cycle life requirements; and whether cycles modulate or are full stroke, etc. . . . and allow BELLOFRAM engineers to specify materials to be used . . . BELLOFRAM will CERTIFY that every seal produced will fully meet your stated requirements.

√ **PERFORMANCE TESTED** — Every lot of BELLOFRAM Diaphragm Seals, so certified, will be subjected to a rigid testing procedure, and each shipment will include a Data Sheet showing the actual test figures on the seals compared with your own specifications.

BELLOFRAM seal specification ranges for design data:

Diameters	.375″ to 6″
Strokes	.100″ to 11″
Working Temperatures	−110°F to 500°F
Proof Pressures	Up to 1000 p.s.i.
Materials	To suit your requirements

"Aircraft quality" BELLOFRAM Diaphragm Seals, when certified, can give added service life and superior performance *at no extra cost.* We will be glad to quote on your needs. For further information, write to:

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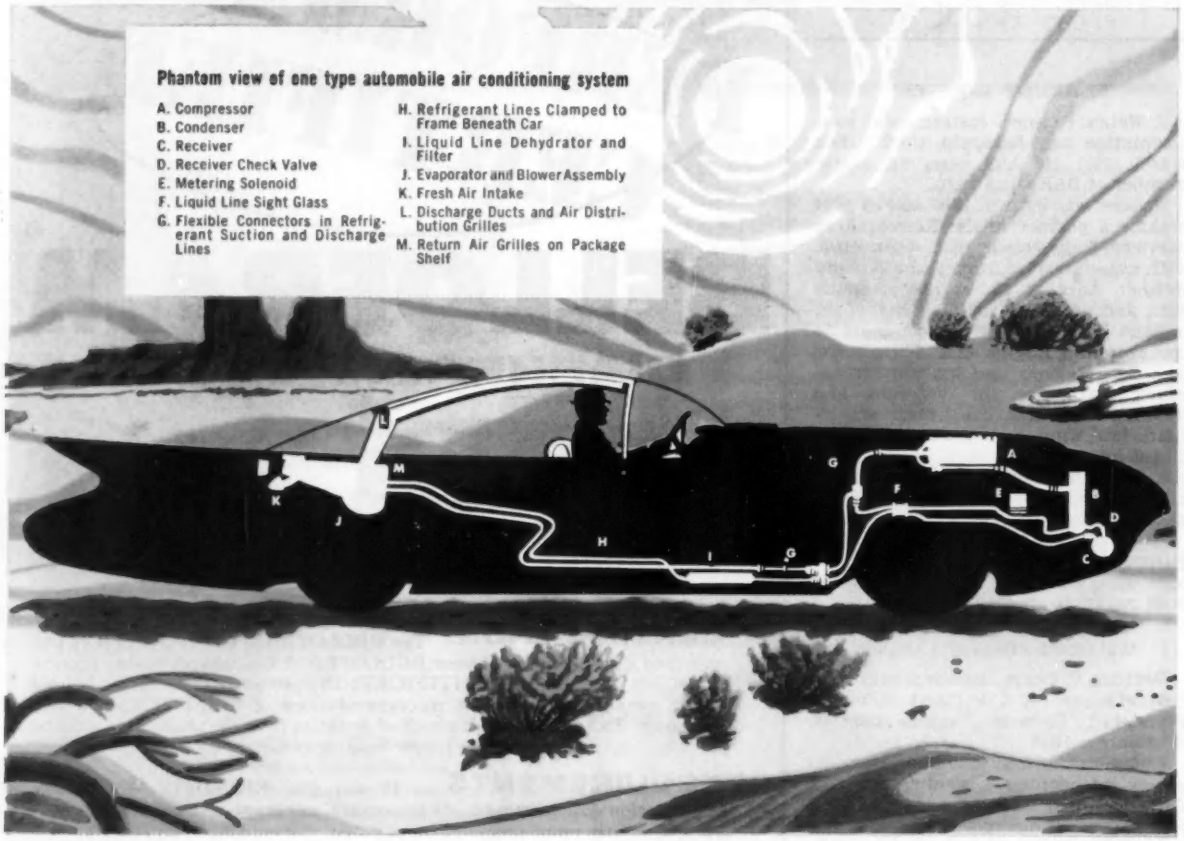
Naugatuck PARACRILS


Phantom view of one type automobile air conditioning system
A. Compressor
B. Condenser
C. Receiver
D. Receiver Check Valve
E. Metering Solenoid
F. Liquid Line Sight Glass
G. Flexible Connectors in Refrigerant Suction and Discharge Lines
H. Refrigerant Lines Clamped to Frame Beneath Car
I. Liquid Line Dehydrator and Filter
J. Evaporator and Blower Assembly
K. Fresh Air Intake
L. Discharge Ducts and Air Distribution Grilles
M. Return Air Grilles on Package Shelf

cool!

Air conditioning an automobile is not a new idea... just one that presented a variety of material specification problems. One of the most important of these problems was the need for a rubber with low enough permeability to be used as a vehicle for commercial refrigerants. This was solved with a Paracril® rubber.

Paracrils are Naugatuck's butadiene acrylonitrile rubbers. Rubbers capable of carrying refrigerants while possessing outstanding resistance to oils, fuels, aromatic hydrocarbons and many hydraulic fluids. In addition Paracrils provide:

- **superior aging resistance, even at elevated temperatures,**
- **high and low temperature flexibility,**
- **outstanding abrasion resistance,**
- **unusual tensile properties,**
- **the best resistance to air and gas permeability.**

For complete information on how the *oil-resistant Paracril* family can help you improve or develop a product, write to us, *today*.

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Division of United States Rubber Company
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Obituaries

Continued from page 139

ERNST W. TORON

E. W. Toron, manager of Willy Vogel GmbH., Germany, died recently.

Toron served with Willy Vogel GmbH. as technical manager and was subsequently made manager. He had been a member of SAE since 1926.

WILLIAM E. ATKINSON

William E. Atkinson, supervisor, North American Trucking Co., and Schmidt Motors, Dawson Creek, B. C., Canada, died April 6.

Atkinson was born in 1907 and became a member of SAE in 1951. He joined North American Trucking and Schmidt Motors in 1949 as service manager and subsequently became supervisor.

WILLIAM C. LITTLE

William C. Little, member of SAE since 1917, died April 7.

Little was born in 1880 and worked in various sales representative capacities before joining the Bearings Co. of America, Lancaster, Pa. He was western sales representative and advertising manager from 1919 to 1947 when he was made Detroit district manager. In 1951 he became manufacturers representative in Detroit, and special sales representative for Banner Die Tool and Stamping Co. in 1957.

CARL J. BOCK

Carl J. Bock, member of SAE since 1920, died April 2.

Bock was born in 1895 and joined the Holt Mfg. Co. in 1916. He served with them until 1920, working as a designer and engineer of Caterpillar artillery mounts. He was one of the designers of the first American military tank used in World War I.

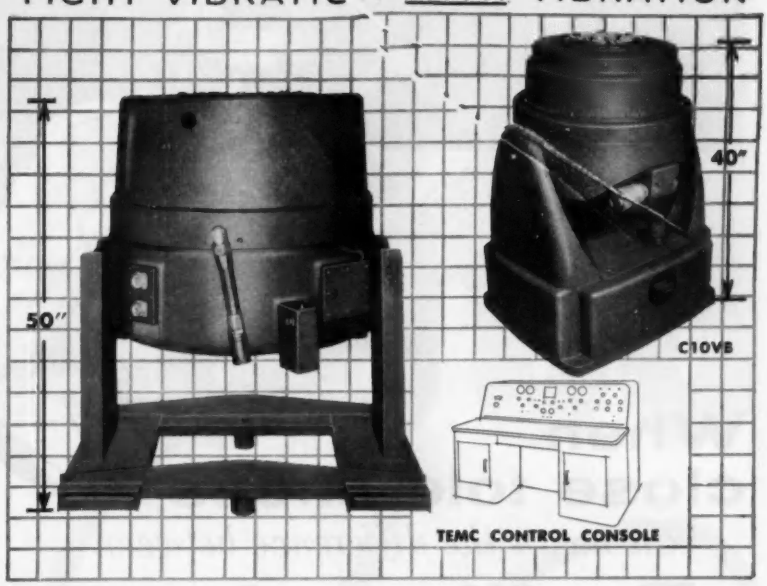
From 1924 to 1927 he worked with the Yellow Truck and Coach Mfg. Co. of Chicago. He then joined the engineering department of General Motors Truck Co. of Pontiac, Mich., which later became a division of General Motors Corp. Bock was with GMC from 1927 until retirement in 1957. In 1948, he was named chief engineer of the GM Truck and Coach Division and resident consulting engineer in 1956.

WILLIAM J. ULRICH

William J. Ulrich, chief product engineer, Paramount Engineering Co., Detroit, has died.

Ulrich was born in 1905 and became a member of SAE in 1953. From 1921 to 1941 he was body designer, Fisher Body Division, General Motors Corp. From 1941 to 1957 he had served with Paramount Engineering Co.

FIGHT VIBRATION WITH VIBRATION



Vibration Testing cuts product development time

Testing components and structures with electrodynamic vibration exciter systems cuts research and development time in aircraft and missile systems. Often within hours, or minutes, the effect of service vibration can be pinpointed.

MB has perfected shaker systems that permit testing to all required specifications, enable engineers to speed product development from blueprint to prototype to production.

COMPLEX MOTION TESTING

Several MB Exciter Systems reproduce complex and random motions. They can subject products to the actual service vibration. The Model C10VB Shaker shown offers the widest frequency range for its force. Model C25HB provides higher forces for higher "g."

ENVIRONMENTAL TESTING

Both the above shaker systems can be used with environmental chambers . . . for "high altitude" and high or low temperature vibration testing. Oil cooled, they don't affect chamber vacuum.

SPECIFICATIONS

MB C10VB System provides . . .
10 "g" on table loads to 145 lbs.
20 "g" on table loads to 57.5 lbs.

Force output:	Band width:
1750 lbs. Sine	5-5000 cps
1050 lbs. RMS	15-2000 cps
3150 lbs. Peak	15-2000 cps

MB C25HB System provides . . .
10 "g" on table loads to 422 lbs.
20 "g" on table loads to 172 lbs.

Force output:	Band width:
5000 lbs. Sine	5-2000 cps
3500 lbs. RMS	15-2000 cps
10,500 lbs. Peak	15-2000 cps

In meeting your requirements, MB offers you advanced designs . . . plus quality construction of shaker, amplifier and control system . . . plus an experienced field service organization.

MB manufacturing company

A DIVISION OF TEXTRON, INC.

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When close tolerances *can mean the difference between* **Profit and Loss**

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PIONEER 921-T
Cast Aluminum Tooling Plate

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Where uncompromising accuracy demands close tolerances and utmost stability, Pioneer 921-T cast aluminum tooling plate is the design engineer's choice. There's a reason. Its special aluminum-titanium alloy composition and method of casting guarantees the absolute uniformity of 921-T, with a coefficient of expansion identical to the material being fabricated, plus freedom from porosity, distortion and casting defects. It is easily sawed, tapped, milled and welded.

Consult the Pioneer 921-T distributor nearest you for complete information, engineering data and prices.

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HOUSTON, TEX.: Vinson Steel & Aluminum Co.
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WALLINGFORD, CONN.: Joseph T. Ryerson & Son, Inc.
WICHITA, KAN.: Industrial Metals, Inc.

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TOOLING PLATE
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EXTRUSIONS

Briefs of SAE PAPERS

Presented below are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. Order from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ each to members, 60¢ each to nonmembers.

AIRCRAFT

Large Lightweight Turbojet Engines, C. A. GRINYER. Presented Apr., 1957, 25 p. General performance of turbojet engines in both subsonic and supersonic flight in relation to aircraft requirements; advantages and disadvantages of bypass engines and small turbojet in relation to large straight jet engine of 18,000-lb thrust; improvement in thrust/weight ratio of large engines made possible by use of titanium, and potentialities of ejector nozzles and turbine blade cooling.

Potential Advancements in Field of Small Aircraft Engines, R. V. HENSLEY, S. R. SHAPIRO, R. CAPIAUX. Presented Apr., 1957, 20 p. To evaluate relative merits of small and large engines comparison is made of data from different sources confined to engines suitable for Mach number range from 2 to 3 and altitudes of 50,000 to 70,000 feet; favorable cycle characteristics established and feasibility discussed; results of data, based on Curtiss-Wright Turbomotor Div design activity show that small gas turbine engine will inherently satisfy requirements.

Introducing New Jet Engine Production with Reduced Lead Times, R. MEDROS. Presented Apr., 1957, 10 p. How to cut lead times by programming of production parallel with further design development when major changes in design development will not occur; four steps of method, used by GE's Aircraft Gas Turbine Div in producing J47 and J79 engines; determination of objective, operating program and its implementation, periodic reporting of progress, and its analysis.

Designing Materials for Future Aerial Vehicles, N. E. PROMISEL. Presented Apr., 1957, 34 p. Factors contributing to materials problems such as speed, temperature, altitude, noise, deteriorative chemicals, availability of materials and use of nuclear power; new tools in processing and fabrication; structural materials for use in range of 400 to 1000 F and above 1500 F; surface modifications; composite, transparent and radome materials; elastomers; specialty fluids and lubricants.

Conway Engine, A. A. LOMBARD.

Continued on page 145

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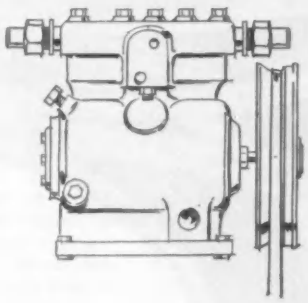

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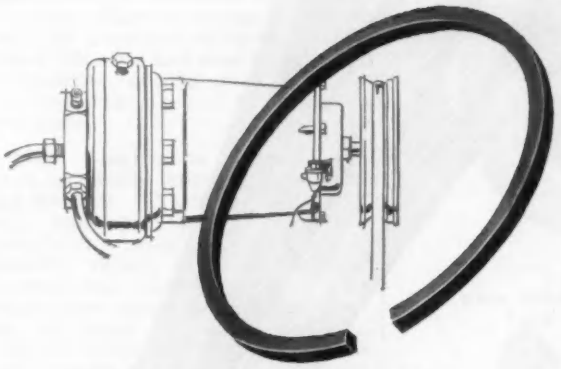

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Briefs of SAE PAPERS (continued)

Presented Apr., 1957, 20 p. Features with regard to civil application in transport field of Conway R.Co.3 engine; historical background and design philosophy adopted by Rolls Royce Aero Engine Div in choosing by-pass principle; application of design philosophy to turbine blades, turbine and compressor disks, compressor blades, main shafts, and main shaft bearings; by-pass duct; control system, and thrust reverser.

Study of Engine Characteristics Best Suited for Commercial Operation, F. W. KOLK. Presented Apr., 1957, 13 p. Basic requirements of commercial aviation engines with special reference to medium to long range high speed jet aircraft; estimated direct operating cost of jet transport; maintenance costs of engine operation; fuel consumption vs weight; effect of holding fuel on overall design of airframe; hot day performance of gas turbine engine.

Molybdenum for Aircraft Applications, R. T. BEGLEY. Presented Apr., 1957, 12 p. Utilization of improved high temperature materials to overcome problems presented by thermal barrier; properties of molybdenum-base alloys for very high temperature applications in advanced aircraft gas turbines; results of engine testing to evaluate oxidation resistance, thermal shock behavior, and erosion resistance of cladding, and to establish factor limiting coating life in actual engine operation.

High Temperature Properties of Vacuum Melted Super Alloys, F. M. RICHMOND. Presented Apr., 1957, 24 p. Most critical applications of high temperature alloys in jet engines is turbine bucket; improved rupture strength and ductility of nickel base super alloys obtained by vacuum melting technique and modifications in nominal chemistry of alloys; tensile and rupture properties of five nickel base vacuum melted alloys (J-1570, GMR-235, Udimet 500, M-252, and Waspaley) for temperature range 1000 to 1600 F; tables.

Pre-Flight Development of Modern Aircraft, H. W. ADAMS. Presented Apr., 1957, 8 p. Douglas Aircraft's development program in production of DC-8 commercial aircraft includes increased amount of structural fatigue studies ranging from tests of large portions of fuselage and panel tests to detail fatigue tests of joints and fittings; types of loads included: pressure cabin cycling, flight gust loads, and acoustic pressure loads; testing DC-8 a-c electric system; testing of sound

Continued on page 146

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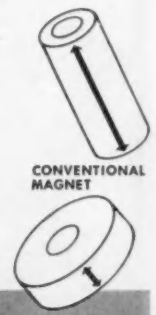

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Briefs of SAE PAPERS (continued)

suppressors and thrust reversers.

Trends in Modern Aircraft Structural Design, E. H. SPAULDING. Presented Apr., 1957, 13 p. Effect of higher performance and use of prop-jet engines created new problems for structural engineers; how they were solved in design of new Lockheed Electra; use of mass parameter in calculating gust alleviation factor; method of controlling propeller drag; new windshield technique; engine nacelle loading; taxiing of fully loaded aircraft; provisions for "fail safe" and long fatigue life; use of large precision die forgings; bleed air ducting for deicing, etc.

Effect of Hot Day Performance on Jet Transport Economics, D. W. FINLAY. Presented Apr., 1957, 10 p. Effects of elevated temperatures upon commercial jet aircraft operation and means of reducing or eliminating operating restrictions.

Thrust Measurement for Jet Transport Operation, M. J. SAARI. Presented Apr., 1957, 13 p. Existing methods of evaluating thrust from engine speed-exhaust gas temperature indications are inadequate; utilization of thrust measuring principles based on nozzle pressure drop parameter provides accurate, simple, and reliable indication of jet thrust for application to jet transport operation; examination of jet thrust equation; diagram of experimental thrustmeter installation.

Successful Containment of High-Speed Turbine Failures, W. W. HOUGHTON, E. R. PHILLIPS. Presented Apr., 1957, 8 p. Design philosophy which when properly applied, presents solution to aircraft turbine wheel burst hazards; approach selected was to build turbine wheel for which wheel speed at burst was accurately controlled, and to reduce effect of burst by limiting particle size and weight; test procedure.

Cruise Control Instrumentation for Turbojet Aircraft, H. F. KIDDER. Presented Apr., 1957, 17 p. How deficiencies of present day cruise control aids for making best use of limited fuel supply can be overcome by integrating display of cruise data into advanced types of flight instrumentation; system proposed by means of which actual values of cruise control parameters and their optimum values are directly comparable on faces of instruments; equipment for cruise data computation and details of system operation.

Turbine-Powered Aircraft Demand New Fuel Handling Techniques, W. S. LITTLE, Jr. Presented Apr., 1957, 14 p. Basic methods to assure clean, dry fuel delivery to aircraft; use of adequate settling time, floating suction and combination water separator/micronic filter at airport storage area, supplemented by water checks, drains and micronic filter at dispensing equipment; experimental jet refueler having 8000 gal capacity and dispensing 750 gal per min through two hoses, currently constructed by Shell, is based on above principles.

Operational Requirements for Future Airports, M. A. WARSKOW. Presented Apr., 1957, 8 p. Master plan for traffic control to serve nation's aviation facilities, prepared by Systems Engineering Team organized by E. P. Curtis who was appointed by President; summary of recommendations which concentrate on operational features of airports, such as runways, visual and electronic navigation aids, taxiways, ground control of aircraft, and improvements and developments needed.

Visual Avoidance of Mid-Air Collisions, W. D. Howell, R. B. FISHER. Presented Apr., 1957, 12 p. Study undertaken by Civil Aeronautics Administration's Technical Development Center, Indianapolis, Ind., to investigate pertinent factors; results and conclusions drawn from investigation of four collision cases; second study of 50 mid-air collisions to establish operational requirements and limitations of collision avoidance system.

Ramjet-Turbojet Propulsion System for Supersonic Flight, R. T. DeVAULT. Presented Apr., 1957, 8 p. Problem of applying propulsion systems to supersonic aircrafts; it is shown that neither turbojets nor ramjets are entirely satisfactory when used by themselves; satisfactory results of combining two powerplants into propulsion system; comparison of performance along operating altitude Mach number paths in terms of thrust and specific fuel consumption only.

Application of Auxiliary Power to Helicopters, D. S. CHATFIELD. Presented Apr., 1957, 5 p. Features of ROR (Rockets on Rotor) system, having total weight of 79 lb, developed by Reaction Motors, Inc.; problems involved in application of rockets to tips

Continued on page 148

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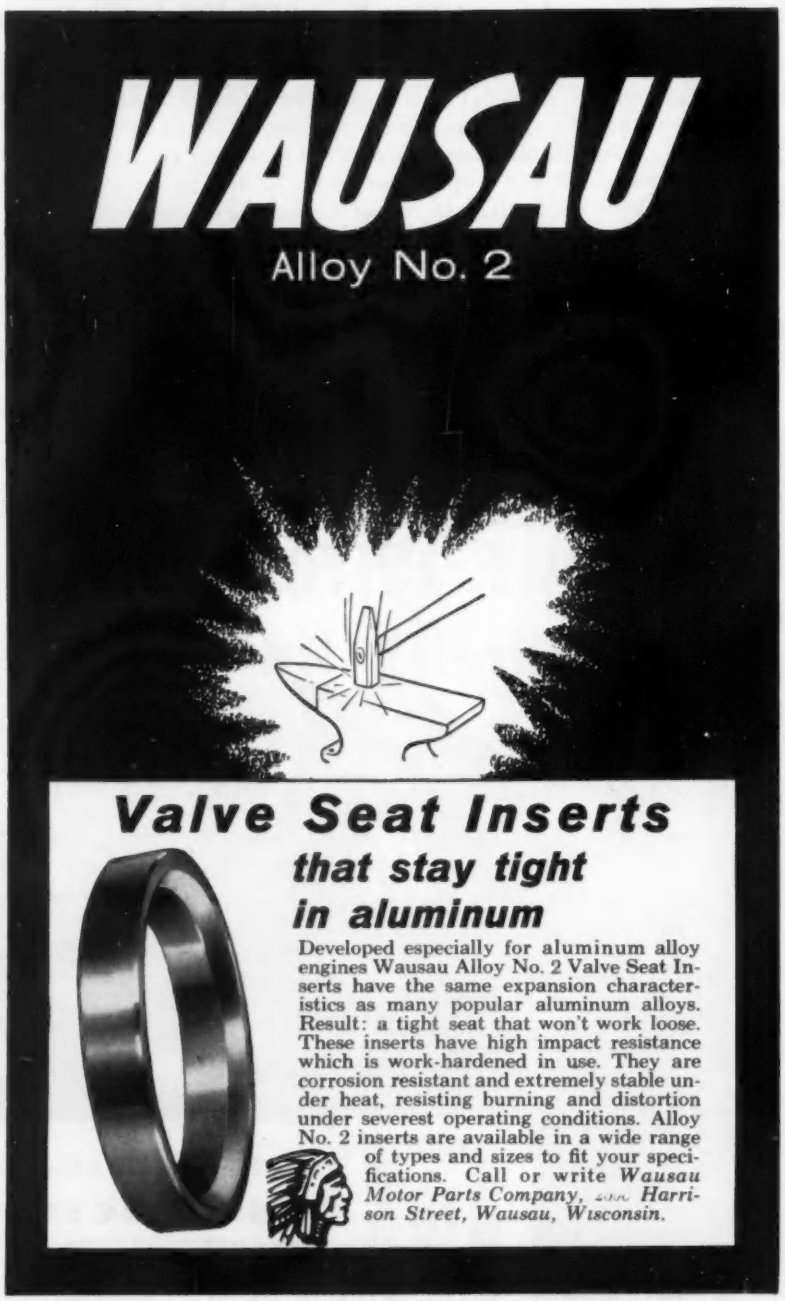
Briefs of SAE PAPERS (continued)

of rotor and location of rocket propellant tank; rocket engines, developing 32 lb of thrust each, operate on high pressure, high temperature decomposition gases of 90% hydrogen peroxide monopropellant; possibility of improving system by "jet flap" principle.

Alloy Titanium in J57 Turboject Engine, W. H. SHARP. Presented Apr., 1957, 10 p. Reasons for its use demonstrated by comparing yield, fatigue, and creep strength of titanium alloys and steels on stress-to-density basis vs temperature; early experience with titanium; application in present and future aircraft engine parts, axial flow compressor blading, rotor parts, etc.; economical aspects and future trends; table of materials composition.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FUELS & LUBRICANTS

Developments in Aircraft Turbine Lubricants, T. F. DAVIDSON, J. H. WAY. Presented Apr., 1957, 9 p. Present experience with aircraft gas turbine lubricants and current problem areas; three categories of possible lubrication systems available for use in future are: circulation oil, throw away, and divided system; properties and composition of future lubricant basestock materials such as esters, mineral oils, silicones, and silanes; tables.

GROUND VEHICLES

Automotive Gasoline Injection, C. H. NYSTROM. Presented Jan. 21, 1957 (Cleveland Sec) 16 p. American Bosch Arma Corp's development program to design very small, compact and simplified, low cost injection pump; development based on using various designs of single pumper pumps for diesel engines by taking from them best design features and incorporating other desirable features such as altitude and temperature compensation, and fuel cut-off during deceleration; principal advantages; diagrams explained in detail.

Fan Noises and Some of Their Cures, K. A. BEIER. Presented Feb. 18, 1957 (Detroit Sec), 7 p. How cooling fan noises which have increased through use of higher speed engines in vehicles, are investigated at Schwitzer Corp.; use of test fan having 18½-in. diam, four blades, 5¼-in. wide blade stock and 32° chord angle; performance of various shape fans of from four to nine blades; advantages of variable speed device in terms of noise level; typical performance curve.

Tomorrow's Dream Car Ride. Presented Jan. 28, 1957 (Detroit Sec) 22 p. Following papers presented: Potentialities of Torsion Bar Suspension, L. M. WALLACE; Air Suspension, R. E. DENZER; Hydro-Pneumatic Suspension, D. IACOVONI.

Rear-Engine Motor Cars—European Point of View, F. PICARD. Presented Mar., 1957, 30 p. Notes on historical development; principal characteristics of four European rear engined cars, built in mass production: Volkswagen, Reault 4CV, Fiat 600 and Dauphine Renault; advantages of rear engine design; construction problems and how they have been solved; statistics of European production; illustrations.

Aiming for Better Headlighting, V. J. ROPER. Presented Mar., 1957, 7 p. To provide seeing distances equal to or in excess of stopping distances, headlamps must be aimed within very close tolerances of exactly correct aim; aiming process is now improved and simplified through addition of accu-

rately aligned aiming pads on front surface of lens which permit use of simple, mechanical aiming devices; method of aiming.

Effective Utilization of Aluminum in Automotive Electrical Systems, T. E. LEWIS, J. C. MEEKINS. Presented Mar., 1957, 11 p. Important applications in present use of aluminum in electrical components are battery cable, condenser, solenoid core sleeve and distributor cap insert; conductor cost savings of up to 50% possible with interleaved strip conductor; application to automotive coils; winding of interleaved strip conductor; methods of joining aluminum; other automotive applications.

Developments in Storage Batteries, H. D. WILSON. Presented Mar., 1957, 11 p. Effects of shift from 6 to 12-v electric systems; dry charged batteries; plastic separators; acid electrolyte supply; pulse charging of wet batteries; corrosion resistant grid alloys; control of charge voltage; automation in battery manufacture.

New Look at Generator Capabilities, P. W. HOUSE. Presented Mar., 1957, 14 p. With increased use of continuous duty accessories, such as air conditioning and power controls, new rating in evaluating automotive generator is necessary which considers combined effect of all factors; generator's ability to meet requirements can be evaluated by two characteristics: its rated output, and load carrying capacity under city driving conditions; procedure of computation, applicable for any generator with any drive ratio.

Rear Engine Mounting: Its Effect on Automobile Chassis, J. R. BOND. Presented Mar., 1957, 19 p. Advantages of rear engine placement in light of recent and future developments; chassis designer has to consider five basic problems, all concerned with effect of new engine position: overall package, suspension and handling, frame design, power package design, and manufacturing and service; tabulation of rear engined cars.

Styling Rear-Engine Automobile, B. STEVENS. Presented Mar., 1957, 5 p. History, functional layout, and psychological public reaction to rear engined cars; design and styling of rear engined American car will be transitional, determined by seating plan and general body architecture; weight and cost will depend upon new material developments and processes; power and performance aspects will be governed by highway design coupled with continuous need for safety.

Mercedes-Benz Racing Cars Design and Experience, H. SCHERENBERG. Presented Mar., 1957, 11 p. Features of racing car W 196, built by Daimler-Benz AG, Germany; use of naturally aspirated 2.5-liter engine producing 290 bhp at 8000 rpm for output of 115 bhp per liter, unsupercharged; scheme of crankshaft and drive; injection pump by Robert Bosch is of 8-cyl in-line type, driven from central power takeoff of engine.

Rear Axles—Today—Tomorrow, R. P. LEWIS, L. J. O'BRIEN. Presented Mar., 1957, 49 p. Discussion confined to axles used in passenger cars and light trucks having similar requirements; general types, such as trumpet, banjo, and carrier type axles; advantages of hypoid gear; lubrication and noise factor; test procedures; axle loading; possible features to be introduced such as locking differentials, high offset axles, and independent rear suspension; table showing features of systems used in Europe; front drive axles and axles for rear engined cars.

Design Features of New Ford Axle, B. GRIFFITH. Presented Mar., 1957,

Continued on page 150

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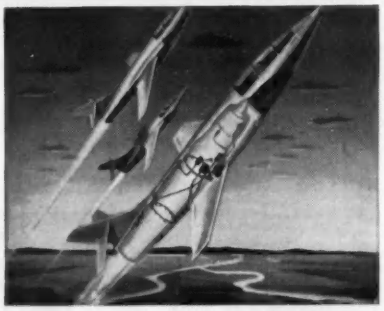

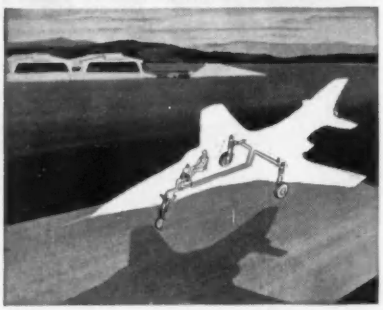

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Briefs of SAE PAPERS (continued)

8 p. Gear development work and testing indicated practicability of 2¼-in. offset axle; new design for use on 1957 Ford and Mercury cars and ½-ton trucks incorporates straddle mounted pinion for improved rigidity of structure and potentially greater torque capacity and life; other construction features; table of design values for two series of 1957 axle gears.

Cadillac's Air Suspension for Eldorado Brougham. Presented Mar., 1957, 23 p. **Pt 1: Experimental Development of Air Spring, V. D. POLHEMUS, L. J. KEHOE, Jr. Pt 2: Application of Air Spring to Production Design, F. H. COWIN, S. L. MILLIKEN.**

Chrysler Torsion-Aire Suspension—Across Board, O. D. DILLMAN, R. R. LOVE. Presented Mar., 1957, 15 p. Steps in development from first torsion bar front suspension A 303 in 1951 to final 1957 production version A-518, used for Plymouth and Dodge design; principles of operation and design details; list of objectives set for suspension, how they were achieved and final results.

MATERIALS

Characteristics of Anodized Aluminum Alloys, R. V. VANDEN BERG, D. J. GEORGE. Presented Mar., 1957, 25 p. Decorative and protective coatings obtained by anodic oxidation processes, known as Alumilite finishes, developed by Alcoa; surface preparation; formation of oxide coating; effect of alloy composition; coloring of anodic coatings; methods of application; performance; specification and acceptance tests; table of nomenclature and characteristics for wrought and cast alloys; suitability to automotive applications.

Automotive Application of Vacuum Metalizing, V. M. STILSON. Presented Mar., 1957, 6 p. Discussion is confined to vapor metallizing on primary surfaces of plastic parts; successful applications include housings, bezels, panel trim, cover plates, clock faces, control panels, dials, knobs, reflectors, etc.; specification of plastic molding composition; steps in surface metallizing; limitations; future trends.

Two New Automotive Topcoats—"Lucite" Acrylic Lacquer and "Dulux 100" Enamel, J. D. PICKENS, T. R. MATTHEWS. Presented Mar., 1957, 9 p. Important properties that must be considered in releasing automotive topcoat finish for sale; performance of du Pont's present 'Lucite" and "Dulux 100"; application and techniques of handling new finishes.

Continued on page 152

What specifications can't tell you about gasket performance

A resilient gasketing material may meet all pertinent government and industry specifications and still fail to provide a satisfactory seal in actual service. At the same time, a material that falls short of one particular specification may well be the most suitable for a certain application. This points up the fact that while specifications have a definite purpose and value, they are not to be relied on as a guide in selecting gasket materials for a new application.

Specification testing is useful as a means of quality control after a suitable gasket material has been found—making sure that each succeeding shipment has the same physical and chemical characteristics. However, it is impossible to develop tests which will cover all the infinite possible combinations under which a gasket will function.

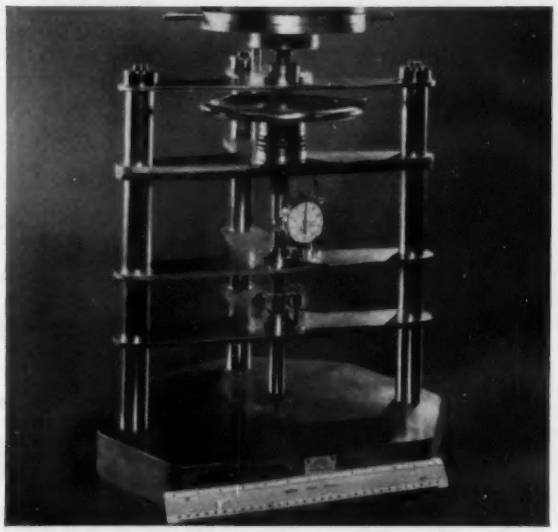
A brief look at some typical tests reveals their shortcomings. For example, many gasket specifications have rigid tensile strength requirements. Tensile strength is easily measured. Yet it usually has no bearing on the sealing ability of a material. Actually a gasket needs only sufficient tensile strength to hold its shape until it goes to work in the flange.

Tests for resistance to liquids are also unrealistic where uncompressed strips of gasket materials are completely immersed in various fluids. Test results may show intolerable changes in such factors as volume, compressibility, recovery, and elongation. In practice, however, only the edge of the gasket is exposed, and the effect of the fluid may be negligible.

This device—called "the spider"—was built at the Armstrong Research and Development Center for use in developing and testing new gasketing materials under varying conditions of flange pressure, internal pressure, and temperature.

Other tests—ream weight and bursting strength for two—have been lifted from the industry that produces the gaskets. Here they have value in helping to maintain quality. But they are of no help to people who use gaskets.

Compounding the difficulties of selection-by-specification is the lack of standardization in test procedures and instruments. In the matter of compressibility alone, there



This Armstrong-developed instrument is used to measure indentation and recovery characteristics of resilient gasketing materials. It is recognized by the National Bureau of Standards and is available commercially. Many laboratories now use this device to help standardize gasket testing.

are the variables of sample size, size and type of pressure foot, and the method and speed of load application.

The habit of buying by specification may delay the use of new and improved gasketing materials. Specifications need to be continually examined to see that they describe the materials of today rather than yesterday.

The common question, "Does it meet our specifications?" should be changed to, "Will it do the job better?" Once you can see that a material works better, establishing new specifications to maintain quality is no problem.

SEND FOR 1957 EDITION OF "ARMSTRONG GASKET MATERIALS"

This 16-page booklet discusses the choice of proper gasket materials and describes Armstrong cork, cork-and-rubber, synthetic rubber, and fiber sheet materials. Look for this booklet in Sweet's product design file. Or for a personal copy, write Armstrong Cork Company, Industrial Division, 7107 Durham Street, Lancaster, Pa.

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Briefs of SAE PAPERS

Types and Forms of Chemically Created Materials for Automotive Engineering, H. A. HOPPENS. Presented Mar., 1957, 4 p. Table listing ten basic types of chemically created materials in plastic category, various forms in which they are produced, and examples of application for automotive use; with chemical industry now ranking fourth in terms of total assets, substantial further growth of chemical application in major component can be expected.

Engineering with Synthetic Fibres, T. J. WALLAG. Presented Mar., 1957, 9 p. Value of rayon, Vicara, acetate, Nylon, Orlon, Darcon, Saran, and polyethylene as soft trim materials; evaluating new materials; requirements outlined for material used for convertible top, headlining, floor covering, and fiber padding materials.

NUCLEAR ENERGY

Navy Nuclear Seaplane, A. D. STRUBLE, Jr. Presented Apr., 1957, 17 p. Reasons which led to development of ANP seaplane concept; application of nuclear power to aircraft propulsion basically involves conversion of reactor heat into mechanical thrust; requirements of nuclear power plant for Navy's purposes; design, research and development problems; solid fueled reactors vs liquid nuclear fuels; space, weight and installation considerations; shielding problems; seaplane refueling by submarine; handling considerations.

PRODUCTION

Modern Machine Tools—Key to America's Future, S. E. BERGSTROM. Presented Jan. 28, 1957 (Cincinnati Sec) 7 p. Historical review of development in United States; its role in mechanization and automation of manufacturing industry; of more than 2 million machine tools according to American Machine Tool Survey, large percentage of tools are old and obsolete; modern methods and machine tools for more productive power per man hr is advocated in order to maintain leadership of United States in industrial field.

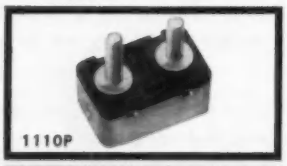
Process Improvements Being Developed Through Manufacturing Research, G. R. FITZGERALD. Presented Mar., 1957, 9 p. Projects of General Motors Process Development Section, aimed at making practical use of new knowledge resulting from research to improve product quality, or working conditions, or to reduce unit cost; examples of various projects relating to better material and labor utilization, and better materials handling methods; application of new discoveries.

These digests are provided by Engineering Index, which abstracts and classifies material from SAE and 1200 other technical magazines, society transactions, government bulletins, research reports, and the like, throughout the world.

ALSO AVAILABLE . . .

. . . 1957 SAE NATIONAL PRODUCTION FORUM, presented March 20. Secretaries' report of 5 panels on "Modern Foundry Practice," "Training of Technicians for Maintaining Automated Machinery," "Integrating Inspection in Automation," "Automating Materials Handling," and "Computer Control of Machines." Available as SP-318 from SAE Special Publications, 485 Lexington Ave., New York 17, N.Y. Price: $1.50 to members; $3.00 to nonmembers.

FASCO
AUTOMOTIVE RESET CIRCUIT BREAKERS
Stop Trouble Before It Starts!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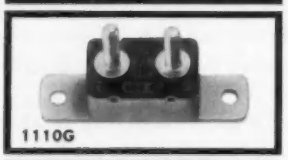
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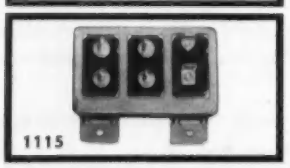
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Yes, these FASCO circuit-breakers protect against overloads and shorts instantly . . . automatically . . . unfailingly . . . thus safeguarding low-voltage electrical equipment operation. And they're available in 8, 10, 15, 20, 25 or 30 ampere capacities . . . for mounting in 1, 2, 3, 4 or 8-unit FASCO brackets.

FASCO Automatic Reset Circuit Breakers are another example of how wise it is to

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A big variety of small, high torque Electric Motors that make ideas work... they're the power behind many of today's push-button devices in modern vehicles. Imaginative American Bosch designing and sound electrical engineering coordinate to provide you with these dependable, compact, decimal horsepower motors. If you have one or a number of small motor requirements in your plans, put the problem up to American Bosch, Springfield 7, Mass. A Division of American Bosch Arma Corporation.

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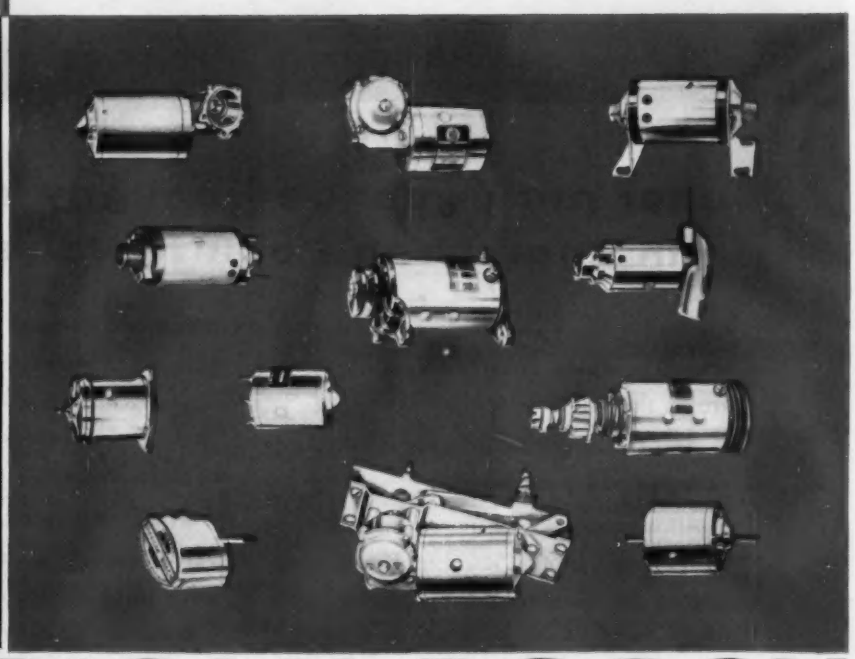
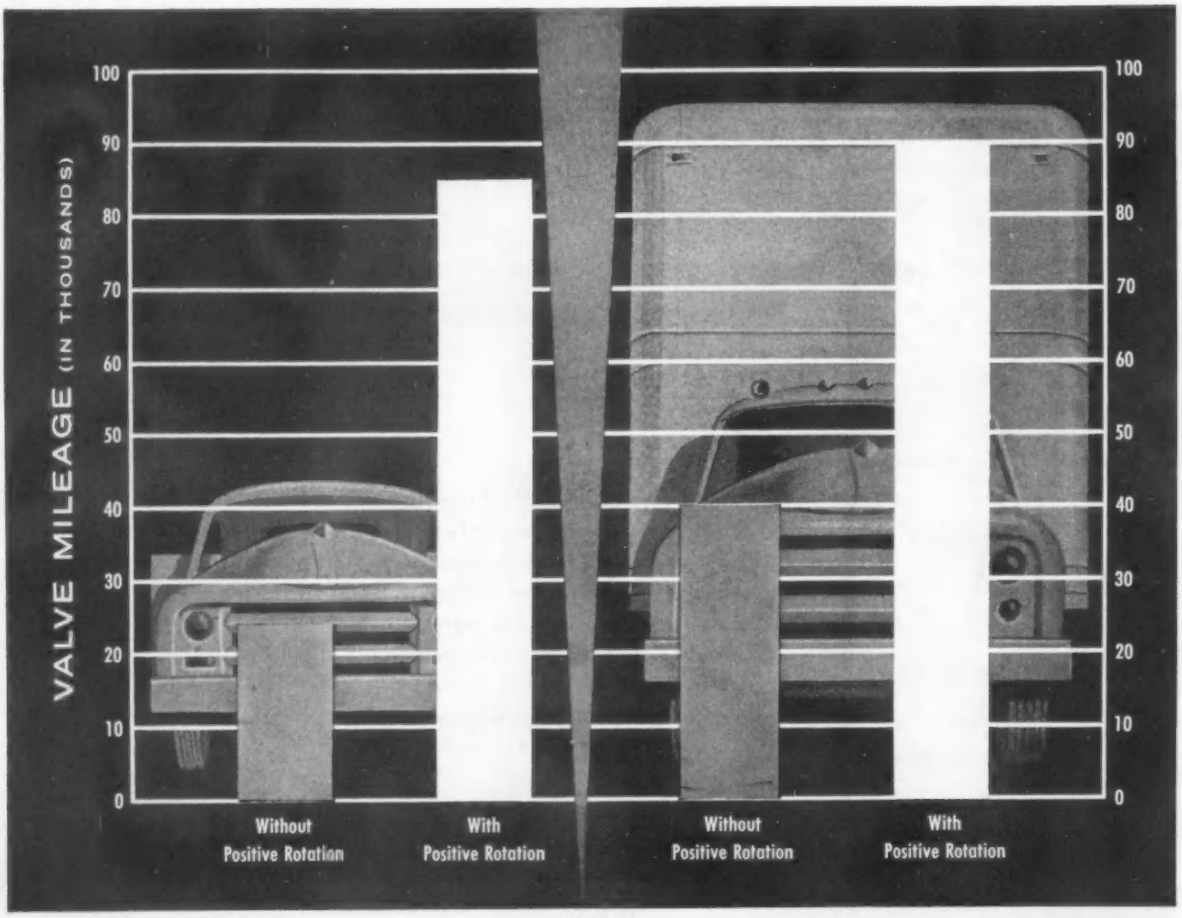
- TOPS



AMERICAN BOSCH



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Valve Division ***Thompson Products, Inc.***

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New Members Qualified

These applicants qualified for admission to the Society between May 10, 1957 and June 10, 1957. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Atlanta Section

Kenneth Watterson Dorman (M), J. O. Holt (M).

Baltimore Section

Emerson K. Patten (M).

British Columbia Section

Jake John Martens (A), Ed Moore (A).

Buffalo Section

Harold T. Dow, Jr. (A), William Vincent O'Neill (J), Wilbur W. Smith, Jr. (M).

Canadian Section

Joseph L. Blais (J), Alan Graham MacNab (A), R. H. Mallory (A), David H. Parker (M), Arthur Paulin (A).

Central Illinois Section

Harry E. Davis (M), Carl W. Hanzi (M), John Robert Hawk (J), Robert J. Huebner (J), Donald C. Kaiser (J), John A. McLain (M), James M. Reisel (J), Gene W. Short (J), James Henry York (J), Donald G. Zook (J).

Chicago Section

Austin M. Breining (J), Edward H. Fisher (M), Robert E. Kay (J), Donald W. Moyer (M), Russell J. Neff (A), Myron E. Pugh (J), John Paul Szabo (J), Svend Erik Tengbom (M), Ralph D. Webb (M), Ross D. Young (J).

Cincinnati Section

Bennette L. Heath (M), Joseph C. Stewart (A).

Cleveland Section

Harold Gold (M), Arthur M. Jaggard (J), Philip A. Kubik (J), Joseph R. Teagno (M), Richard B. Twickler (M), John M. Washburn, III (J), Daniel Richard Wessman (J), Albert P. Wuchter (M).

Dayton Section

John Dean Kiner (A), John F. Pribonic (M), William Dean Walther (M).

Detroit Section

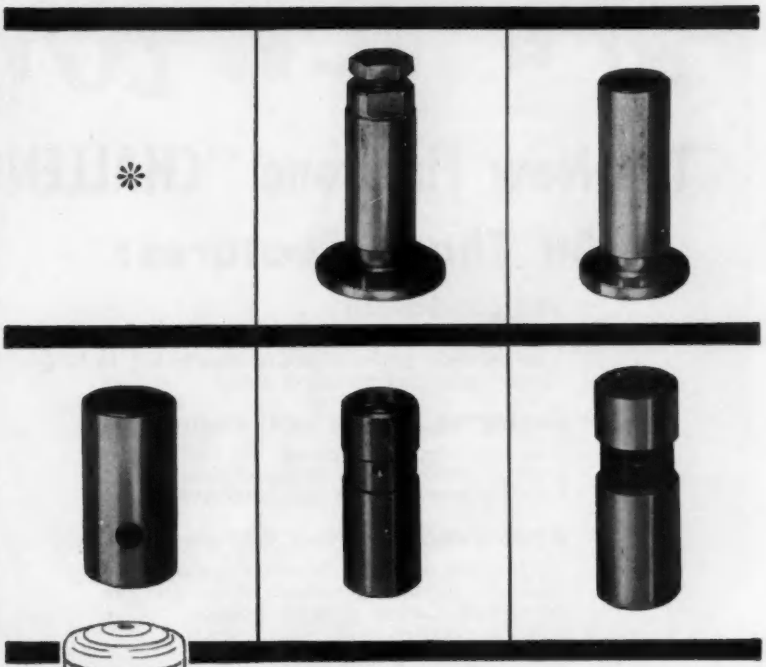
Thaddeus M. Alexander (M), Zelmar Barson (M), Burwyn B. Bender (J), Leo Joseph Berger, Jr. (J), George Bernard (M), Hugh J. Blecki (J), Charles V. Bliven (M), Ralph C. Bolz (M), Edward K. Bowen (M), Murray Burnstine (J), James Vincent Chabot (M), John R. Christenson (M), Arthur M. Clark (M), Robert S. Cliffton (M), Ford Louis Coleman, Jr. (A), James Edward Cousins (A), Leon L. Dodge (A), Sedgwick S. Field (A), D. E. Garrison (A), Julius Grigore, Jr. (M), Gerald F. Hause (M), Charles I. Hodgson (M), John D. Jenks (M), Ernest A. Johnson (J), William J. Kelly (M), Christopher Merritt Kennedy (J), George W. Landon (J), Albert M. Lane (M), Kuldip Mehta (J), Joseph Eugene Mila (J), Richard J. Omalaske (M), Freddie Donald Randall (M), J. J. Roberson (A), Norman O. Roff (M), Robert A. Rogers (J), Vincent Ryszewski (M), Joseph H. Schultz (A), Marcus Claude Smith (M), William M. Spreitzer (M), Myron E. Stanton (A), William P. Stewart, Jr. (M), Roy Stott, Jr. (M), Reid K. Taube (A), James D. Vaseau (M).

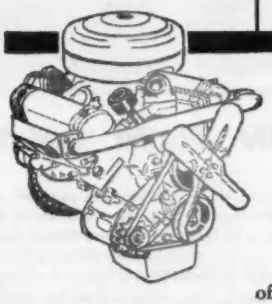
Hawaii Section

William Santos (A), Don Seaton (A), Homer W. Widener, Jr. (A).

Continued on page 159

JOHNSON *tappets*





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Continual experimentation and excellent manufacturing methods show a steady product improvement that make JOHNSON TAPPETS worthy of your consideration. Only proven materials, covering a range of steel, chilled iron, and various iron alloys are used in the manufacture of JOHNSON TAPPETS, providing greater strength, light weight and increased wear resistance. Serving the AUTOMOTIVE — AIRCRAFT — FARM — INDUSTRIAL — MARINE Industries.

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A New Lightweight Truck Rim

at a NEW LOW PRICE!

The New Firestone "CHALLENGER" Two-Piece Rim

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Lightweight, but extra rugged. No dead weight . . . You get extra payload because they're 8% to 12% lighter than most standard rims.

★ **Easier to Mount and Demount...**
New simplified construction . . . only one piece to remove when changing tires. Beads loosen easier. A real time-saver.

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No sacrifice of center to center spacing on duals . . . meets requirements of tire and rim association. Can be used with chains.

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Nothing compromised but the price. No other rim offers so much value . . . it's the lowest-priced quality rim on the market today.

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Baltimore 25, Md.—Standard Wheel & Rim Co.
Birmingham 3, Ala.—Wheel, Rim & Parts Co.
Boston 15, Mass.—New England Wheel & Rim Co.
Buffalo 3, N. Y.—Frey, The Wheelman, Inc.
Cedar Rapids, Ia.—Des Moines Wheel & Rim Co.
Charlotte 1, N. C.—Carolina Rim & Wheel Co.
Chicago 16, Ill.—Stone Wheel & Rim Co.
Cincinnati 3, Ohio—Rim & Wheel Service, Inc.
Cleveland 1, Ohio—The Motor Rim Mfrs. Co.
Clifton, N. J.—Wheels, Incorporated
Columbus 15, Ohio—Hayes Wheel & Spring Service
Dallas 2, Texas—Southwest Wheel, Inc.
Davenport, Iowa—Stone Wheel & Rim Co.
Dayton 2, Ohio—Rim & Wheel Service, Inc.
Denver 1, Colo.—Quinn & McGill Motor Supply
Des Moines 12, Iowa—Des Moines Wheel & Rim Co.
Detroit 8, Mich.—H & H Wheel Service, Inc.
Detroit 2, Mich.—Rim & Wheel Service Co.
Evansville, Ind.—Auto Wheel & Rim Service Co.
Fargo, N. Dakota—Wheel Service Co.
Fargo, N. Dakota—Pioneer Rim & Wheel Co.
Fort Wayne, Ind.—Wheel & Rim Sales Co.
Grand Rapids 2, Mich.—Rim & Wheel Service Co.
Harrisburg, Pa.—Standard Wheel & Rim Co.
Hartford 6, Conn.—Connecticut Wheel & Rim Co.
Houston 2, Texas—Southwest Wheel, Inc.
Indianapolis 2, Ind.—Indiana Wheel & Rim Co., Inc.
Jacksonville, Fla.—Southeast Wheel & Rim Co.
Kansas City, Mo.—Borbein, Young & Co.
Knoxville 17, Tenn.—John A. Harris & Son, Inc.
Lancaster, Pa.—Standard Wheel & Rim Co.
Los Angeles 23, Calif.—Motor Rim & Wheel Service
Los Angeles 58, Calif.—Wheel Industries, Inc.
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Memphis 3, Tenn.—Beller Wheel, Brake & Supply
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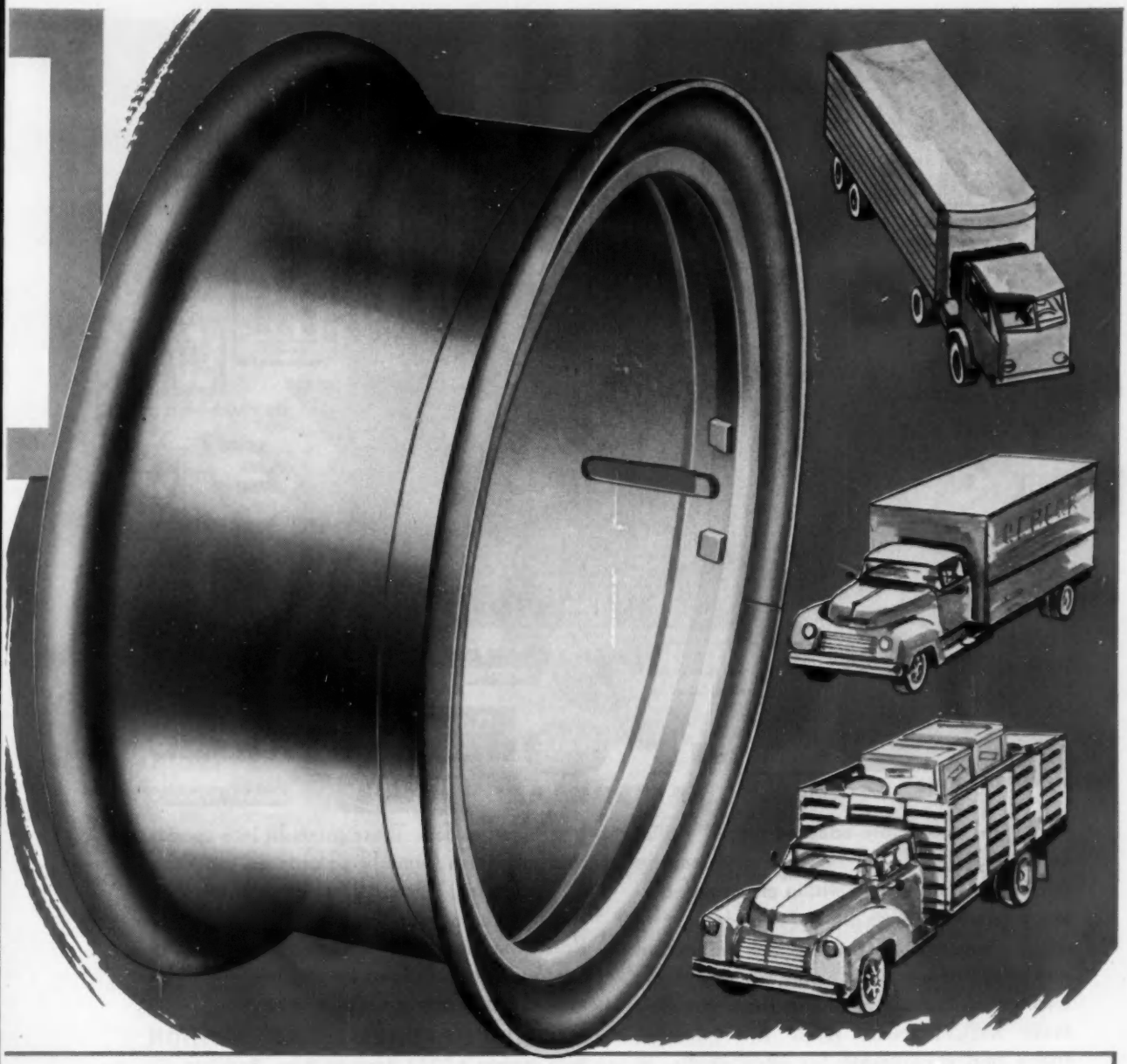
FIRESTONE STEEL PRODUCTS



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New Orleans 19, La.—Southern Wheel & Rim Service
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Omaha 2, Neb.—Morgan Wheel & Equipment Co.
Omaha 2, Nebraska—Omaha Rim & Wheel Co.
Peoria 2, Ill.—Peoria Wheel & Rim Co.
Philadelphia 4, Pa.—Kay Wheel Sales Co.
Philadelphia 30, Pa.—Thomas Wheel & Rim Co., Inc.
Pittsburgh 13, Pa.—Wheel & Rim Sales Co.
Portland 9, Oregon—Auto Wheel Service
Portland 14, Oregon—Six Robblees', Inc.
Providence 3, R. I.—New England Wheel & Rim Co.
Raleigh, N. C.—Carolina Rim & Wheel Co.
Richmond 20, Va.—Dixie Wheel Company
Rochester 7, N. Y.—Frey, The Wheelman, Inc.
St. Louis 8, Mo.—Borbein, Young & Co.
St. Paul 4, Minn.—Wheel Service Co.
Salt Lake City 1, Utah—Henderson Rim & Wheel Service
San Antonio 2, Texas—Southwest Wheel, Inc.
San Francisco 10, Calif.—Motor Rim & Wheel Service
San Francisco 3, Calif.—Wheel Industries, Inc.
Seattle 22, Wash.—Motor Wheel & Parts Co., Inc.
Seattle 14, Wash.—Six Robblees', Inc.
South Bend 18, Ind.—Wheel & Rim Sales Co.
Spokane 2, Wash.—Bearing & Rim Supply Co.
Springfield, Mo.—Borbein, Young & Co.
Springfield, Ill.—Illinois Wheel & Brake Co.
Syracuse 1, N. Y.—Wheels, Incorporated
Tacoma 3, Wash.—Six Robblees', Inc.
Toledo 2, Ohio—Wheel & Rim Sales Co.
Wichita 5, Kansas—Borbein, Young & Co.

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Calgary, Alberta—Fisk Tire Service Co., Ltd.
Edmonton, Alberta—Alberta Wheel Distrib., Ltd.
Edmonton, Alberta—Clark's Service Garage
Montreal 34, Quebec—Auto Wheel & Supplies, Ltd.
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Vancouver 10, B. C.—Wheels & Equipment, Ltd.
Winnipeg, Manitoba—Fort Garry Tire & Serv. Co.

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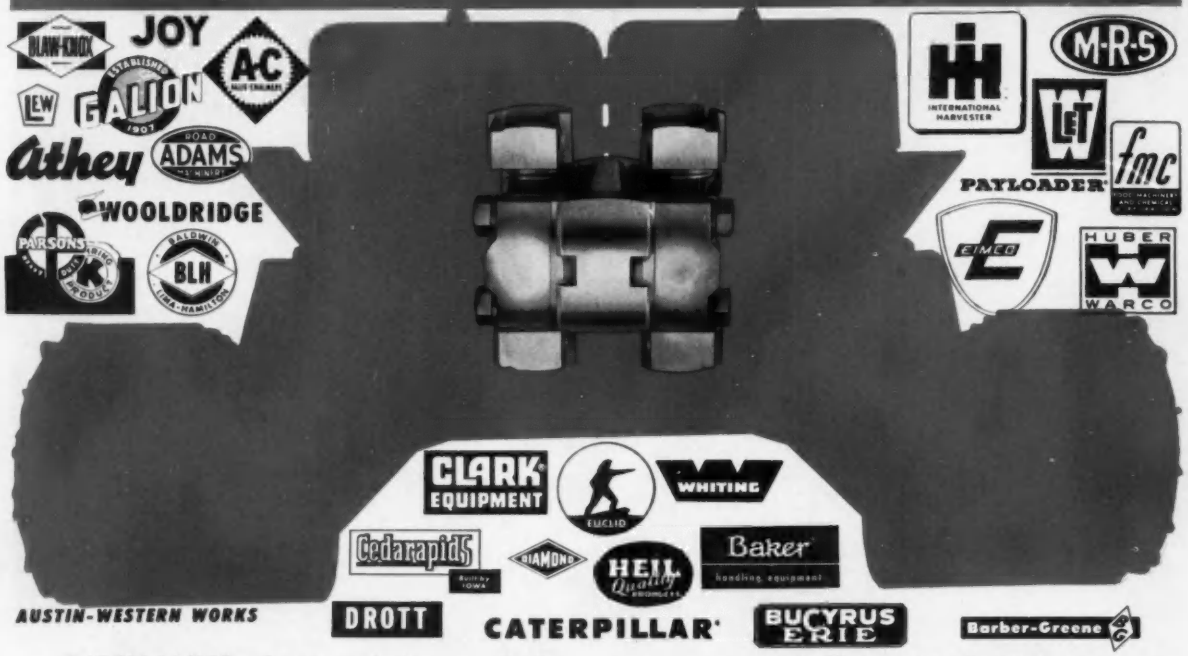
COMPACT



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UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

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Kansas City Section

Robert G. Glenn (M), Willard Clarke Hargiss (M), H. E. Mathews (M), Donald Matthews (M), George M. Mierley, Sr. (M), Charles H. Stockdale (M), Robert E. Weiler (M).

Metropolitan Section

G. Renfrew Brighton (A), Joseph H. Budd (M), John C. Cox (M), Frank P. Crowley (A), John G. McDonough (A), Stanley L. Novak (M), Burt L. Smith (A), Siegfried W. Speidel (M), George T. Stern (M), John V. Wiman (M), Edwin C. Younghouse (M).

Mid-Continent Section

William O. Banks (A).

Mid-Michigan Section

Robert J. Stiehl (M), Clifford G. Studaker (M), Karl J. Windberg (M).

Milwaukee Section

Albert E. Buchholz, Jr. (M), Robert P. Daykin (M), James A. Donohue, Jr. (J), Clyde A. Furgason (M), Gerald Haft (J), Raymond E. Hren (A), Ralph Hansen Miller (M), Philip E. Myers (M), Lawrence C. Oertle, Sr. (M), Theodore H. Pulles (M), Donald Keith Stephenson (J), Donald H. Stevens (M), Robert E. Zuleger (M).

Montreal Section

Andre Guimond (J), Edward L. Switzer (A), George Thimens (A).

New England Section

Daniel Fairchild (M), Mark Hallinan (J), Richard C. Sedlak (A), Allen Clark Smith (J), Houston F. Tyner (A).

Northern California Section

Ralph W. Leininger (A), Hans E. Menter (A), James Fred Richards (A), William A. Selby (M), Robert W. Spencer (A).

Northwest Section

E. Everett Mansfield (M), James Portugal (J).

Oregon Section

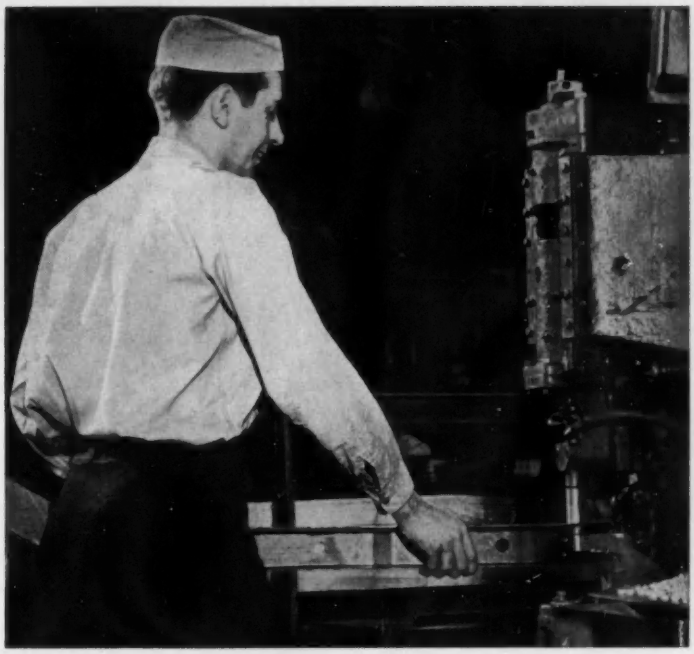
Wilbert C. Freer (A).

Philadelphia Section

Albert Ambrosch (M), George J. Balling (M), Joseph A. Ewing (M), Donald C. Rowe (M), Robert M. Wells, Jr. (A).

Continued on page 160

MIDLAND
WELDING NUTS



take seconds to apply... save hours of labor!

If you make a component part of an ultimate metal assembling operation requiring bolting in hard-to-get-at places, Midland Welding Nuts may well be the answer to simple, secure fastening later on. The practical Midland method anchors the nut in the exact location, ready to receive the bolt. There's no guesswork and cross-threading becomes impossible.

It's easy to apply Midland Welding Nuts.

Just insert the collar in the hole for bolt or screw, resistance-weld the nut in place, and the nut is anchored for the life of the job. Nuts can be automatically fed to the welder to save time.

Midland Welding Nuts assure close fit of metal parts. They can't work loose, causing annoying rattles. Also, parts can be removed easily and quickly for replacement or repair without threat of losing nuts. Assembly workers prefer them because they turn stubborn, difficult jobs into simple, easy to handle projects, often converting two-man tasks into one-man operations.

Write or phone for complete information!

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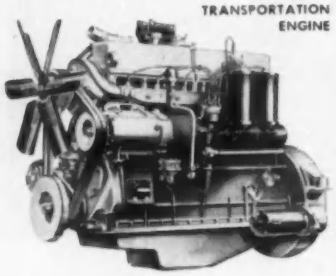
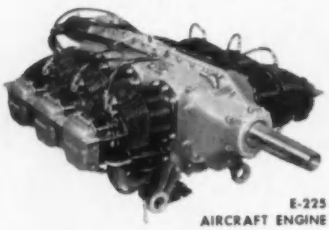
Ever since 1902, Continental Red Seal engines have been proving their dependability in a steadily-lengthening list of special-purpose machines. Today's broad and diversified line includes power plants—for operation on all standard fuels—for countless applications on land, at sea and in the air. There are liquid-cooled models for transportation, industrial and agricultural use; air-cooled horizontally-opposed models for business and utility aircraft, and a complete line of air-cooled four-cycle engines—vertical and horizontal shaft for use in lawnmowers, garden tractors, pumps and similar machines.

S6749
TRANSPORTATION ENGINE



In the Continental line of transportation engines there are 32 models from 26 to 240 horsepower. The industrial line includes 47 basic models from 15 to 280 horsepower —all at closely-spaced power levels.



E-225
AIRCRAFT ENGINE

In the aircraft engine line there are 10 models ranging from 65 to 320 horsepower.

•

Continental builds an outstanding line of small air-cooled engines—2 to 4 h.p. For information on these models, address Air-Cooled Industrial Engine Division, 12800 Kercheval Avenue, Detroit 15, Michigan.

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South Texas Group

Leroy M. Huth (A).

Southern California Section

Bernard Joseph Barbeito (J), William L. Ihrig (M), Joseph La Torre (M), James A. Ray (J), Charles G. Ryder (A), 1st Lt. Earl S. Suters, Jr. (J).

Southern New England Section

Anthony J. Bosco (J), Malcolm A. Buell (M), George P. Harrington, Jr. (J), Lawrence J. Trudeau, Jr. (J).

Texas Section

Michael D. Keen (J), Martin J. Mulroy (A), Marion R. Rue (M), Karl Ludwig Sanders (M), Hale William Stevenson (M), Ralph R. Uhrmacher (M).

Texas Gulf Coast Section

Lester L. Ingram (A), 2nd Lt. Richard Jere Shopf (J).

Twin City Section

Richard L. Holmes (M), Nealy Homer White (M).

Virginia Section

Ashby T. Atkinson (M).

Washington Section

Lawrence D. Reimer, Jr. (J).

Western Michigan Section

Nelson T. Levings, Jr. (J), James C. Pearl (J).

Wichita Section

Wendell E. Miller (M).

Williamsport Group

Tom G. Conway (M), Edwin James Ounsted (M).

Outside Section Territory

Harry A. Bancroft (M), Waldean W. Grauerholz (J), Roger J. Hageboeck (M), Everett H. Lee (M), James R. Liebhart (A), Eugene E. Richards (A), William E. Rolls (A), William L. Smith (A), Robert M. Williams (M).

Foreign

Gerhard D. Drauz (J), Germany; John J. Hoesly (M), Japan; Tom Joy (M), England; Herman Kramer (A), Holland; Harumoto Sugisaka (M), Japan.

Applications Received

The applications for membership received between May 10, 1957, and June 10, 1957, are listed below.

Atlanta Section

Eugene L. Newman.

Alberta Group

Albert A. Nicholls.

Baltimore Section

Paul E. Henninger, Sr., Gilbert L. Wolf.

Canadian Section

Francis E. Conlin, H. B. Dunthorne, Edwin A. Kozicki, Carmine Luciani, James Warner Marshall, Arthur Sledin Moss, William Philip Schoenau.

Central-Illinois Section

Joseph M. Bertschinger, Eugene W. Duvendack, Hubert Alvin England, Byron S. Fierce, Mark Edward Kowalske, Julio Eladio Laredo, Tracy W. Peck, Andrew B. Pulliam.

Chicago Section

George Elliott Anderson, John F. Antrim, Harry Richard Callaway, Jr., Ronald J. Flattum, Paul Edward Josenhans, Arthur Harold Krumhaus, Richard Gerald Lee, Hubert N. Leipzig, Jay R. Sturm.

Cincinnati Section

Ronald Duane Irvin, Alex B. McLennan.

Cleveland Section

Charles V. Martin, Andrew P. Papanek, James L. Strong, Jr., W. Keith Switzer, J. Paxton Van Sweringen.

Colorado Group

Peter John Konesky, William J. Perry, Harry M. St. John.

Dayton Section

W. R. Alley, David Biermann, Fount F. Daugherty, Robert J. Kick.

Detroit Section

Peter G. Anderson, Eugene Ash, Edward K. Benda, Ralph W. Bishop, Frederick W. Burgie, Jr., Karl S. Burnside, Murray William Bursott, Dale LeRoy Byerly, Bruce R. Cable, Richard E. Clay, Arthur E. Cook, Donald Cox, George A. Davis, Robert F. Diederich, Stephen Anthony Dier, Fred H. Edgar,

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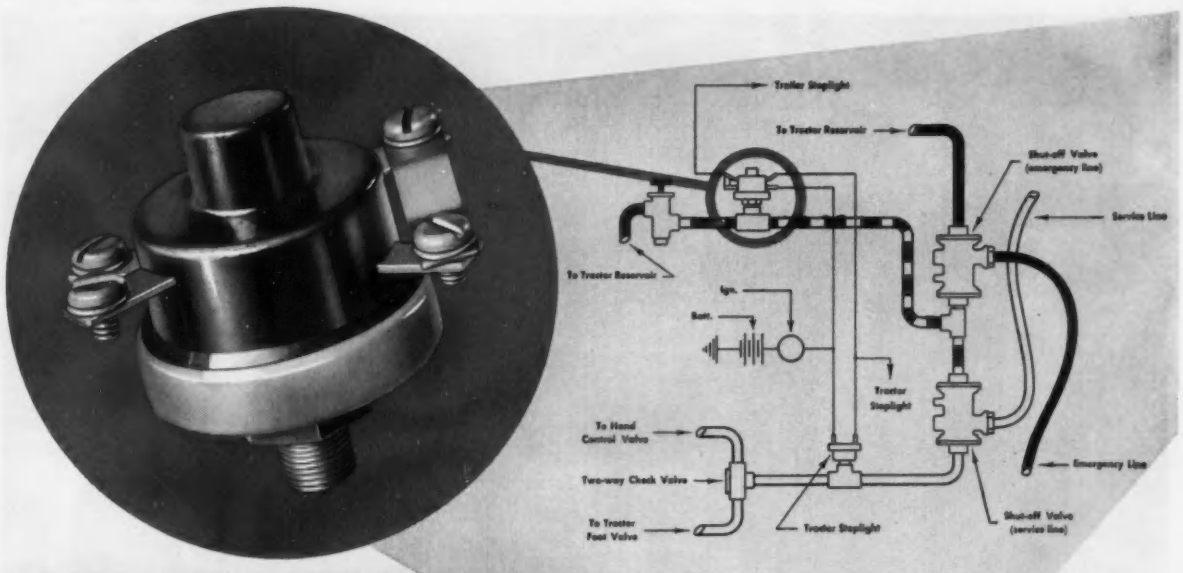
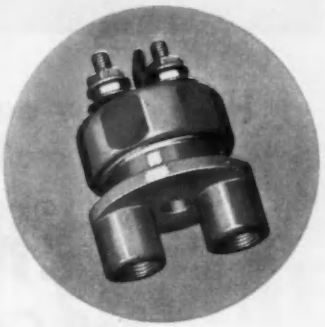


MIDLAND'S Trailer Emergency Stoplight Switch Is Your Answer To ICC Requirements

YOU WILL CONFORM to the ICC's emergency braking stoplight requirement for combination vehicles quickly, effectively, economically by equipping your tractor units with Midland's newly perfected double throw stoplight switch—the switch designed to actuate the trailer stoplight when the brakes are applied by emergency controls.

This switch operates in conjunction with the standard stoplight switch currently installed in vehicles equipped with air brakes. Whereas the standard switch is operated by pressuring the service line, Midland's new emergency stoplight switch goes into action when an emergency application is made and pressure is exhausted from the emergency line.

The new switch can be installed very simply, requires very little change in piping and wiring. For full details, contact your nearest Midland Distributor — or write the factory direct.



Also available — Midland's new vacuum suspended stoplight switch, which provides trailer stoplight actuation on combinations equipped with vacuum brake systems . . . It is simple in construction, dependable in operation. Durable yet compact, it can be installed easily and economically . . . It's a fact—Midland has the most *complete* line of tractor and trailer braking equipment in the industry!

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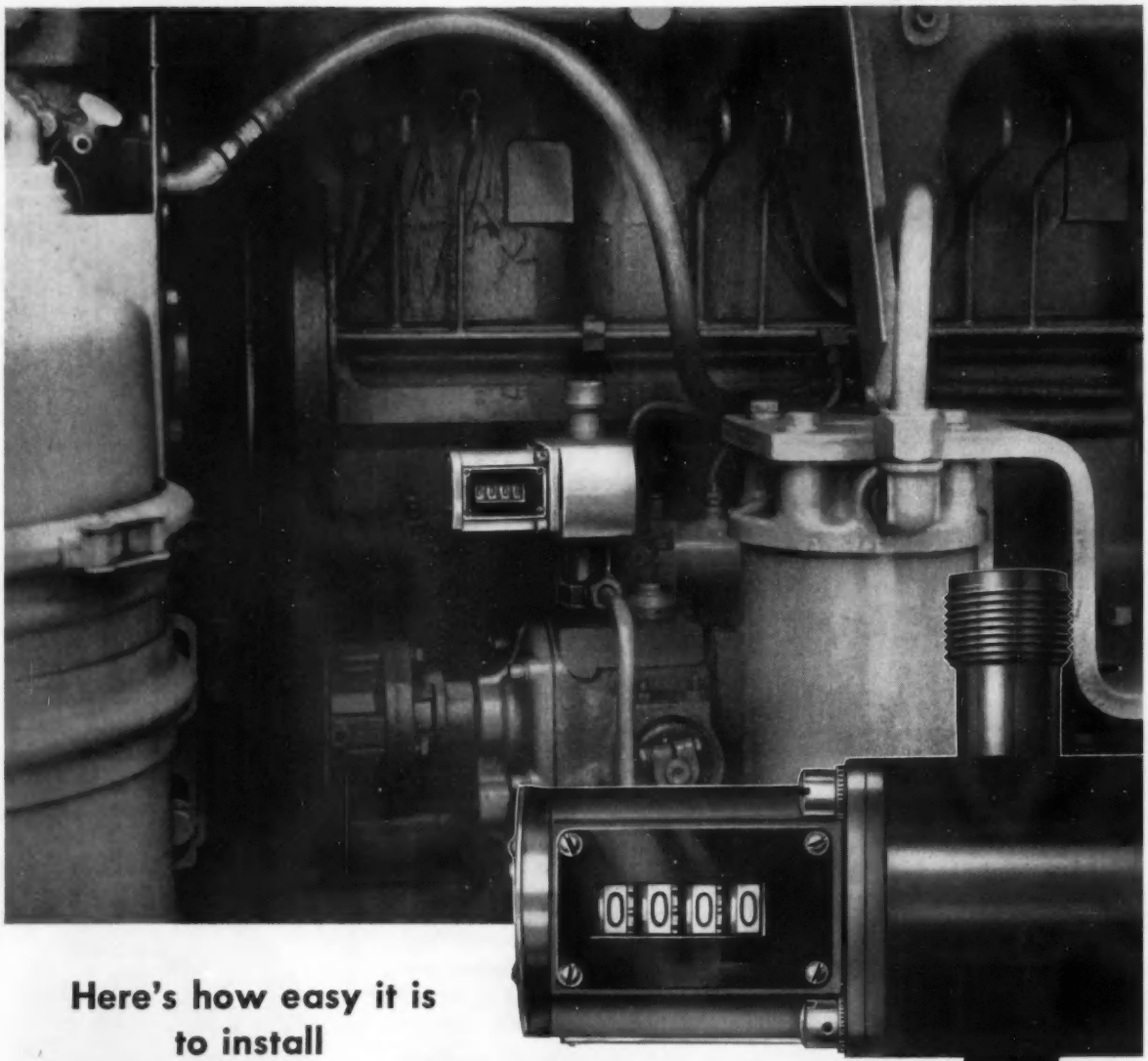

Here's how easy it is to install

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Rev-Counters

...with the New "Tach Take-Offs"

On any engine having a tachometer take-off, Veeder-Root Rev-Counters can be installed in a position which is readily accessible for easy reading . . . so the man who reads the counter doesn't get all messed up or get a crick in his neck.

In fact, with these new attachments, Veeder-Root Rev-Counters make it easy for anyone to see how your equipment is living up to its guarantee . . . when routine maintenance is coming due . . . and to get other valuable facts-in-figures.

You can count on Veeder-Root to help you engineer these adaptable counters not only into engines, but into generators, compressors, heaters, and other equipment. And you will find . . . as other manufacturers of power-units have found . . . that when you build in Veeder-Root Counters, *you build up sales.*

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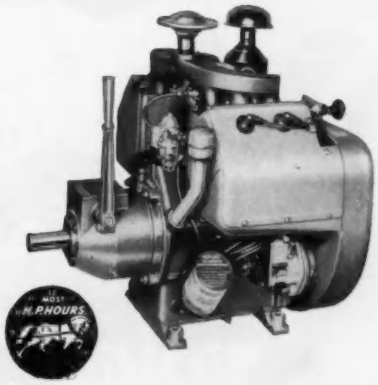

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MASSIVE construction . . . materials of exceptional durability . . . and efficient design are outstanding Spicer Heavy-Duty Clutch features. Trucks . . . fire apparatus . . . earth movers . . . industrial and railroad applications . . . these giant power-delivery jobs have been handled by Spicer Clutches for over 25 years.

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Ask Dana engineers to help meet your particular power transmission requirements. Dana has the clutch experience and the ability to do the job... the result of over 50 years of development in power transmission.

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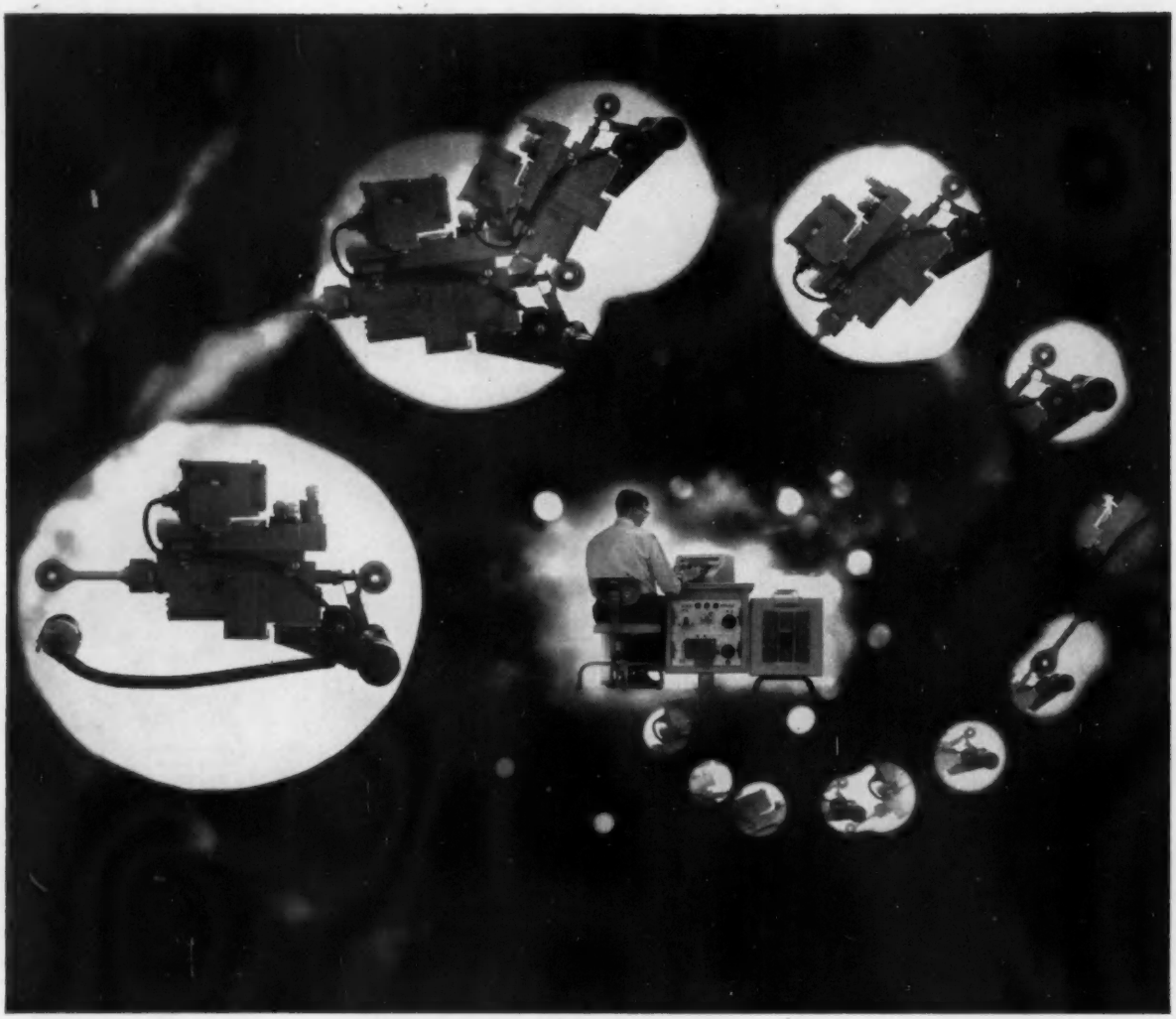

Man's electro-mechanical partners are bringing his ideas to life faster...better...at less cost

Today one of industry's most formidable tasks is to streamline and shorten the time-consuming process that transforms ideas into exciting new products.

Never in man's history has this embryonic period needed to be shortened more than now—when technological superiority could very well be the world's best hope for peace.

And nowhere is this challenge being met more energetically than in the development and production of automatic control systems at AUTONETICS. A whole new breed of electronic and electro-mechanical tools and techniques is being evolved to shorten lead time. A notable example is *Numill*, AUTONETICS' new tape-directed numerical machine-tool control system. *Numill* is entirely digital, and can convert a numerical engineering description into a prototype configuration—quickly, economically and with consistent accuracy.

Standardized "postage-stamp" circuits allow engineers to mockup even highly advanced designs almost as simply as they would plug in an electric shaver. And AUTONETICS' data processing equipment can simulate a wide range of operational missions, as well as solve the most involved mathematical problems in minutes instead of days.

AUTONETICS' ability to save time and money between concept and product delivery is reflected in every area of its electro-mechanical technology: flight controls, inertial navigation, armament controls, computers, and other complete systems for the military and industry.

For detailed information, or for employment in this dynamic field—write: AUTONETICS, Dept. SAE-73, 9150 E. Imperial Hwy., Downey, Calif.

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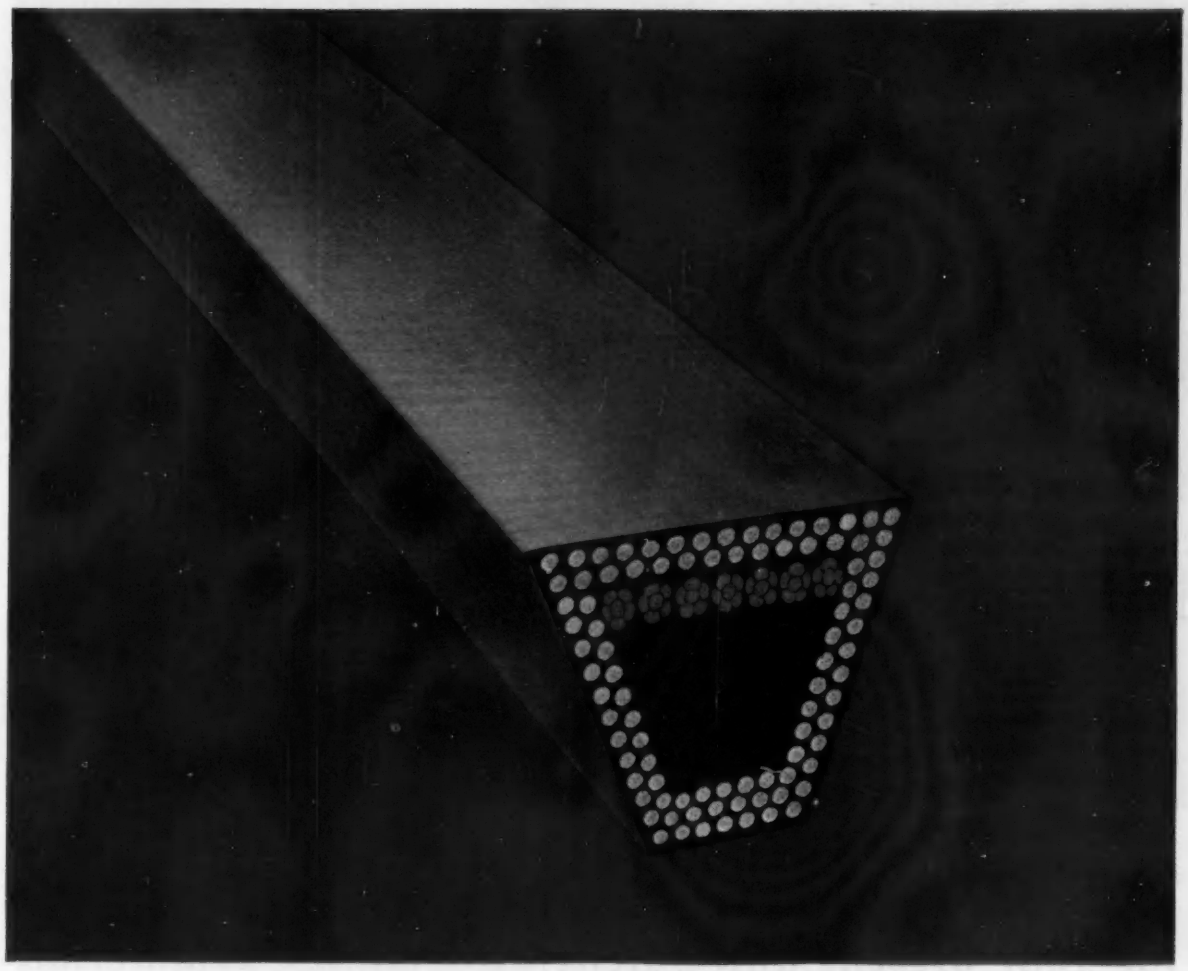
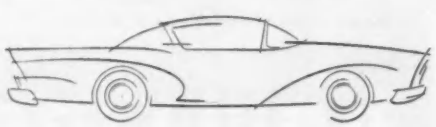
AUTOMATIC CONTROLS MAN HAS NEVER BUILT BEFORE

AUTOMOTIVE V-BELTS



Quiet . . . smooth . . . vibration at the vanishing point



Unerring electronic controls; new methods of curing; the facilities of the largest and most modern plant devoted exclusively to the manufacture of endless transmission belts—these are the factors that bring to the automotive industry the one V-belt that erases vibration to the vanishing point.

The U. S. V-Belt contributes greatly to the silent and efficient operation of fan, generator, water pump, power steering and air conditioning . . . all part and parcel of today's finest automobiles.

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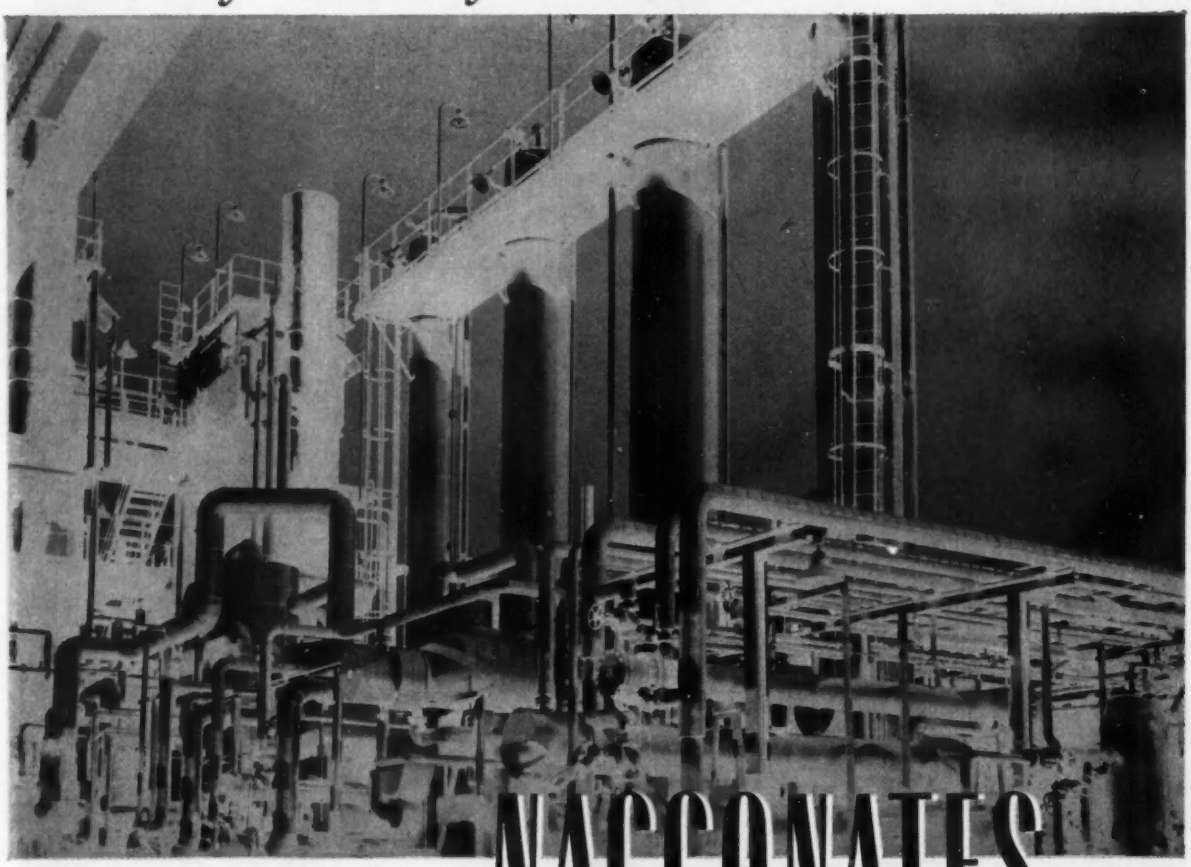

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- ☐ Application Data Sheet 41156—Flexible Foams
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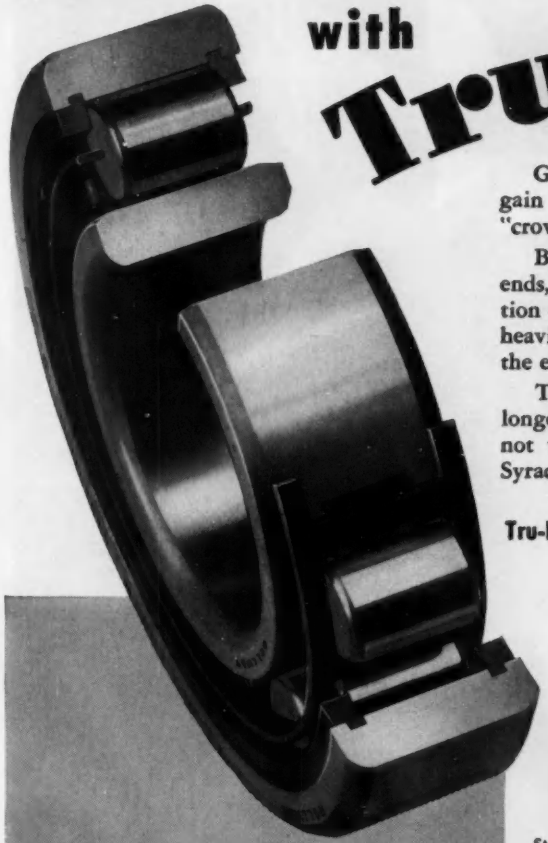
Now...load rate your bearings at higher values

with Tru-Rol CROWNED ROLLERS

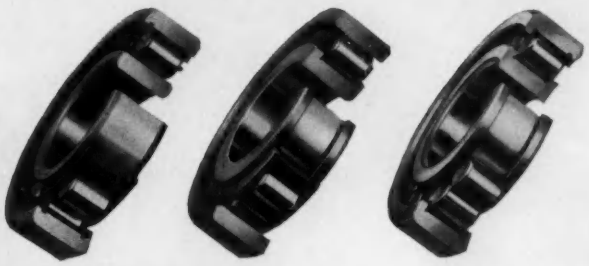


Greater capacity . . . longer life . . . or a precisely balanced gain of *both* factors. That is the choice offered you by the "crowned" rollers of Tru-Rol bearings.

By finish grinding a carefully selected crown radius on roller ends, Rollway relieves high stress areas, insures uniform distribution of load over the entire length of the roller. Rollers can take heavier loads without excessive end-fatigue, and are less subject to the effect of slight misalignment or deflection.

The result is load rating at higher values for greater capacity, longer service life . . . or both. If this choice interests you, why not write for the complete story. Rollway Bearing Co., Inc., Syracuse, N. Y.

Tru-Rol Bearings with crowned rollers are available in 3 types

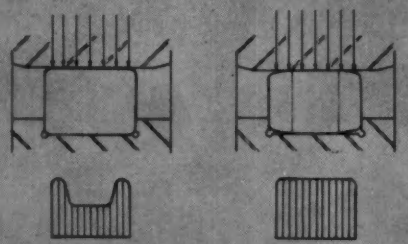


Stamped Steel Retainer with Guide Lips

Segmented Steel Retainer

Full Roller

Comparative Stress Patterns under Uniform Loads for Straight and Crowned Cylindrical Rollers



Stress pattern for a straight cylindrical roller under load. Note uneven end-loading.

Stress pattern for crowned roller under load. Crowning radius is exaggerated for clarity.

● Rollway engineering service is available to help you select exactly the right bearings for your needs. Write us.

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COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

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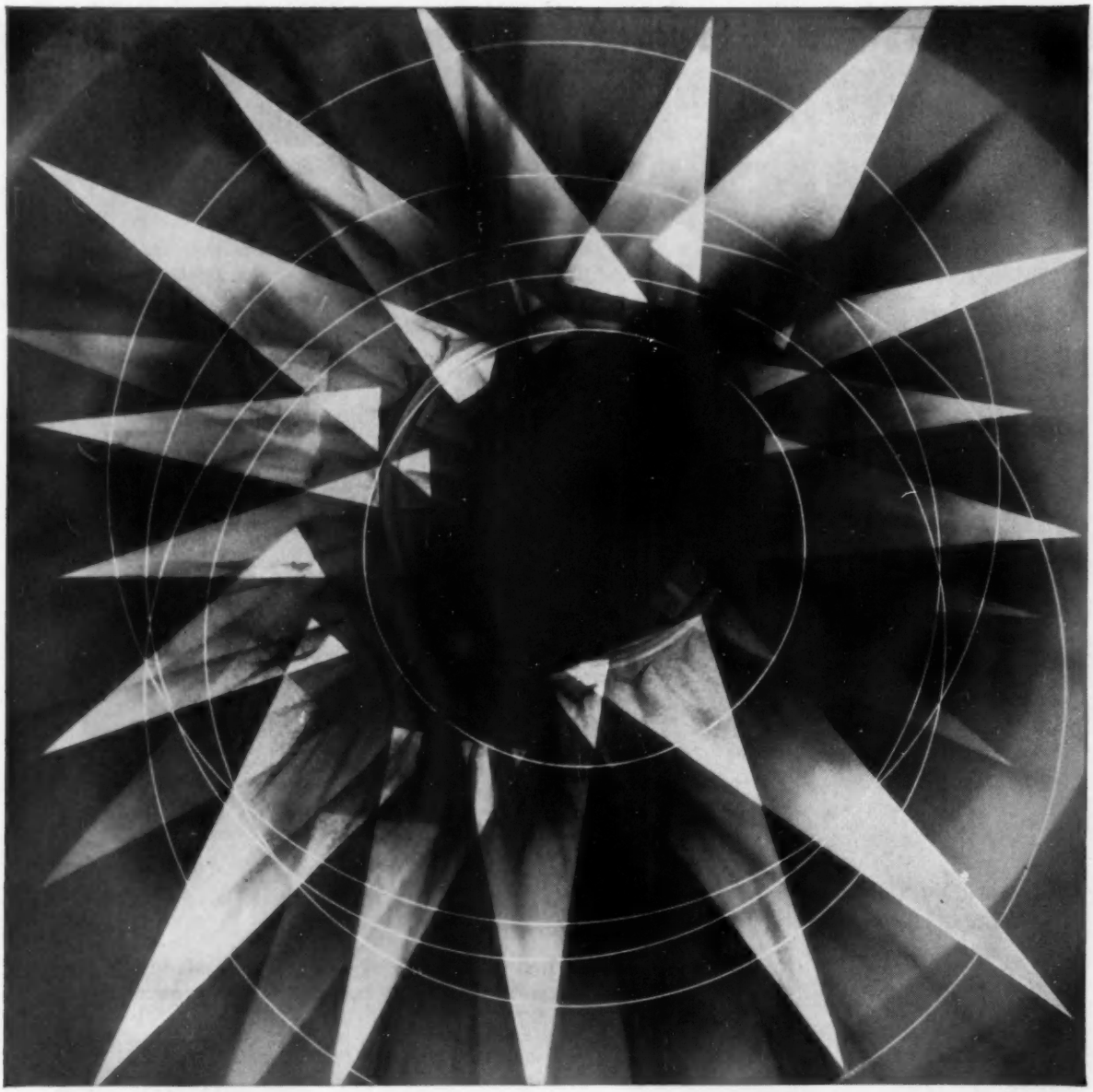

breaking the barriers
with Utica Vacuum Metals

Today's challenge lies in developing *metals* and *means* of cracking the thermal barrier.

The metals problem has already been partially solved by superalloys produced through Vacuum Melting. This process, as developed by Utica, has yielded such super refractory alloys as Udimet 500—a clean, pure alloy combining unsurpassed stress-rupture life with superior high tensile strength in the 1200° F to 1800° F range. *At 1600° F, Udimet 500 has a tensile strength of over 100,000 PSI.*

In addition to making new superalloys, Utica Metals Division of Kelsey-Hayes upgrades existing alloys through vacuum melting. Kelsey-Hayes Co., Detroit 32, Michigan.

VACUUM MELTING
provides these properties

- *High temperature corrosion resistance*
- *Increased ductility*
- *Extreme cleanliness*
- *Precise chemical control*
- *Longer stress-rupture life*
- *Increased tensile strength*
- *Better fatigue resistance*
- *Greater yield strength*
- *Greater impact resistance*
- *Greater creep properties*

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Aviation, Automotive and Agricultural Parts • Hand Tools for Industry and Home.

15 PLANTS / Detroit and Jackson, Michigan; McKeesport, Pennsylvania; Los Angeles, California; Windsor, Ontario, Canada Springfield, Ohio — 2 plants — (SPECO Aviation Division) • Utica, New York — 4 plants — (Utica Drop Forge and Tool Division) Davenport, Iowa (French & Hecht Farm Implement and Wheel Division)

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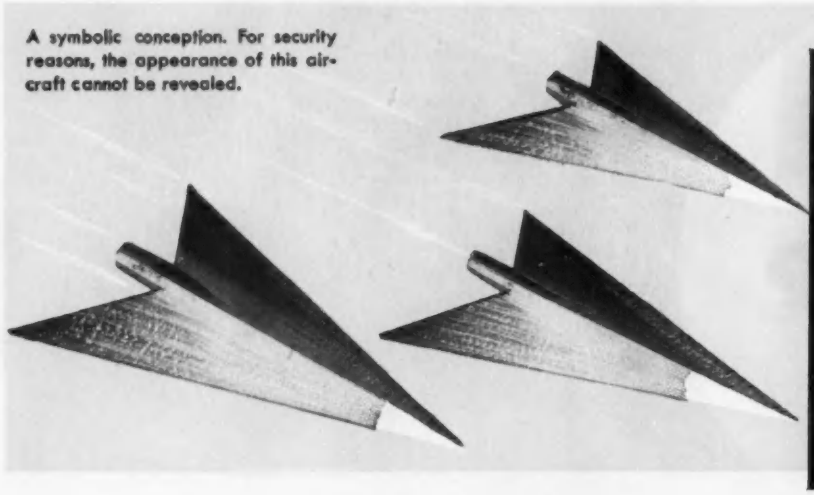
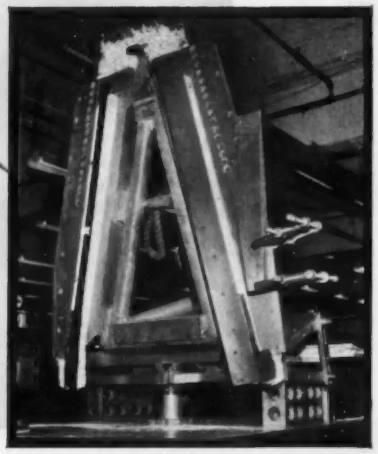


A symbolic conception. For security reasons, the appearance of this aircraft cannot be revealed.



A master drill and setting gauge, showing use of Epon resins to duplicate compound curves and contours.

In building the supersonic Arrow . . .

Avro Aircraft, Limited saves time and money with

EPON® RESIN

dies, tools, jigs, molds and fixtures

Avro Aircraft, Limited—developing Canada's supersonic Arrow—is achieving major savings with Epon resin tooling.

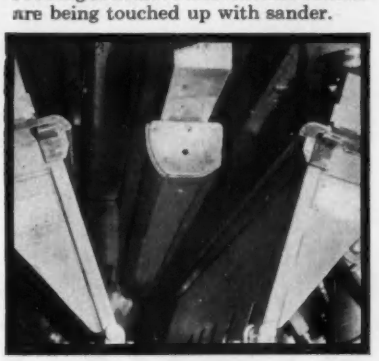
Epon resins provide faster, lower cost preparation of stretch dies, forming tools, drop hammer dies, jigs, duplicate master die molds, checking and assembly fixtures. Avro reports that in making dies of Epon rather than metal, manpower requirements are two-thirds less, which is reflected in correspondingly great savings in the unit cost of tooling.

The Epon resins have an ideal combination of properties for tooling applications. To list just a few:

- Exceptional dimensional stability, high impact strength, excellent resistance to abrasion, minimum residual stress in cured parts.
- Ease and speed of preparation.
- Low shrinkage in filled formulations, assuring perfect master reproduction; minimum warping and stresses.
- Adaptability to repairs and design changes.
- Minimum finishing requirements for smooth surfaces.

Like Avro, other leading manufacturers report savings as high as 80% with Epon resin tools and dies—for *production* as well as experimental and short-run work. Can you make comparable savings in your own operations? Find out by writing for technical literature on Epon resins for tool and die applications.

Epon-faced die requires only hand rubbing to achieve smooth finish. Radii are being touched up with sander.



Stretch die, with Epon resin facing of involved contours, ready for run on 800-ton press.

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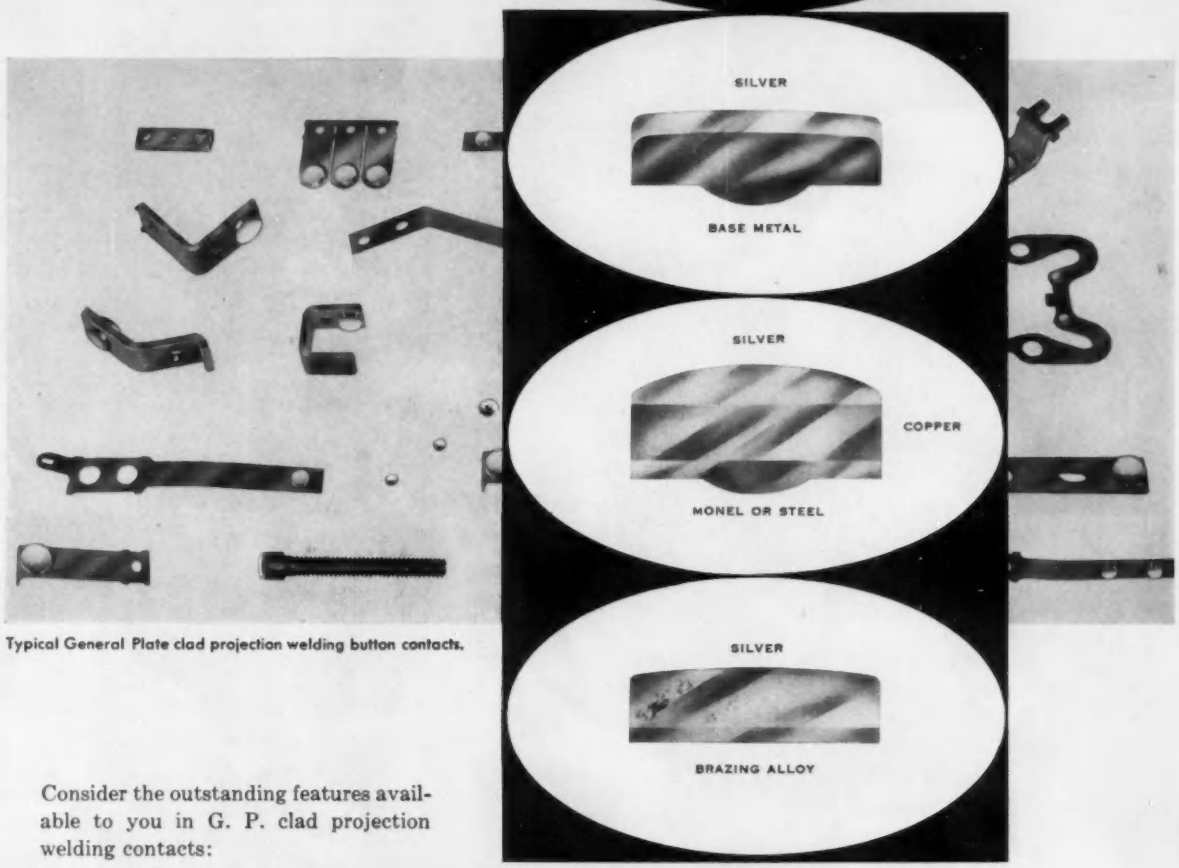
Help You Boost Product Performance — Cut Product Costs



Typical General Plate clad projection welding button contacts.

Consider the outstanding features available to you in G. P. clad projection welding contacts:

- **TRIPLE CLAD CONSTRUCTION.** Three ply types have copper between contact face and backing for higher specific heat at lower cost — reduces surface temperature — prolongs operating life.
- **WROUGHT METAL FACES.** Contact face materials in both two and three ply types are work hardened in manufacture — resist deformation — give more operations — better tolerance control.
- **WIDE CHOICE OF MATERIALS.** Contact face materials include silver and platinum group metals and their alloys—silver cadmium oxides—refractory metal mixtures. Backing materials include steel — nickel — nickel-silver and monel.
- **WIDE CHOICE OF SIZES.** Tremendous assortment of standard sizes available to meet all dimensional requirements.

Back of this unusual product versatility, is General Plate Division's team of contact experts — ready to help you get the best performance at the lowest cost. Your inquiries are invited.

You Can Profit by Using G. P. Clad Metals

METALS & CONTROLS CORPORATION

General Plate Division

1107 Forest Street, Attleboro, Mass.

FIELD OFFICES: NEW YORK, CHICAGO, DETROIT MILWAUKEE, LOS ANGELES

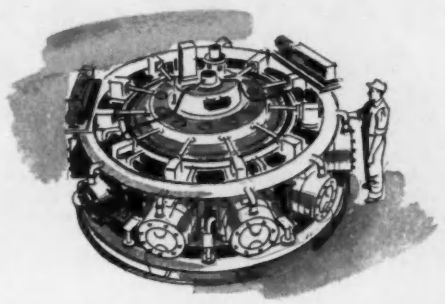
"On a half-million car year,

we'd save over $88,000!"

"Here's where we can save some money, Charlie ... on wrist pin bushings. We can buy bronze or aluminum for about the same price per pound. But we get three times as many bushings out of a pound of aluminum. It figures out to a savings of over 2¢ per bushing. On an 8-cylinder car, we save about 17¾¢. If we have a half-million car year, that's $88,750. Not bad!"

Wrist pin bushings of Alcoa® Aluminum *are* the key to important savings. To mean something, these savings have to be achieved at no sacrifice in performance. Modern engines must be capable of turning over much faster to meet advertised horsepower ratings. It has been estimated that the pressure on the wrist pin bushings can be as high as 8,000 to 10,000 psi.

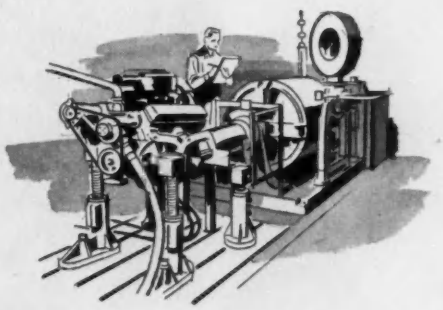
Can aluminum take this pounding and hold up? You bet! No other bushing material is in the same league with aluminum for load-carrying capacity. Aluminum bearings are first choice for the really heavy-duty services such as diesel engines. They last 20,000 hours and more in this tough service.



Nordberg Manufacturing Company now uses aluminum wrist pin bushings in one of their diesel engines. Performance on all counts has been superb.

Aluminum is an ideal wrist pin bushing material. It runs cool because of its excellent thermal conductivity. There's little likelihood of seizure with aluminum bushings. It is a very ductile metal and conforms easily to misalignment or nonparallelism.

There's no corrosion problem with aluminum bushings. Additives in oil can't hurt it. No protective coating is necessary. Aluminum is an easy material to fabricate. All operations may be performed with readily available, standard tools.



As part of the development program, Alcoa engineers ran actual tests on aluminum wrist pin bushings installed in engines. In one test, a 1955 engine was equipped with aluminum bushings and run on a dynamometer on a breakdown schedule. Performance was excellent. Wear rates were equal or superior to those obtained with other materials.

If you haven't already begun an investigation of this important means of saving cost at no sacrifice in performance, we suggest that you do so. Alcoa stands ready to offer full assistance to manufacturers who want to take advantage of aluminum's many excellent qualities. Our Development Division will work with you on the goals you've set for your new models. Aluminum Company of America, 1844-G Alcoa Building, Pittsburgh 19, Pennsylvania.

ALCOA ALUMINUM gives every 1957 car more **GLEAM AND GO**

Don Walter, B.S. M.S., achieved an outstanding academic record at Cal Tech, Class of '40, while earning seven varsity letters. Today as Vice President in charge of Engineering and Van Nuys Operations, Don utilizes his technical and teamwork background to lead Marquardt's engineering and development manufacturing. He is an example and exponent of Marquardt's management philosophy.

ENGINEERING MANAGEMENT = OPPORTUNITY AT MARQUARDT

Every day, professional engineers are finding *outstanding* career development opportunities at Marquardt Aircraft. Because, at Marquardt, there is no ENGINEER/BARRIER.

Marquardt is guided by a management team with an *engineering* philosophy.

This management team is familiar with, understands and respects the contributions of engineers.

This engineering philosophy eliminates all traces of the ENGINEER/BARRIER—that invisible management level beyond which engineers cannot advance.

Professional engineers interested in joining a company which offers this management team and this engineering management philosophy are invited to write *that* letter to Jim Dale, Professional Personnel, 16555 Saticoy Street, Van Nuys, California.

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For jet and rocket aircraft engines, wings and surfaces that are subject to extreme conditions of heat, friction and corrosion, where the metal *must stand up* . . . design it, improve it and protect it with McLOUTH STAINLESS STEEL.

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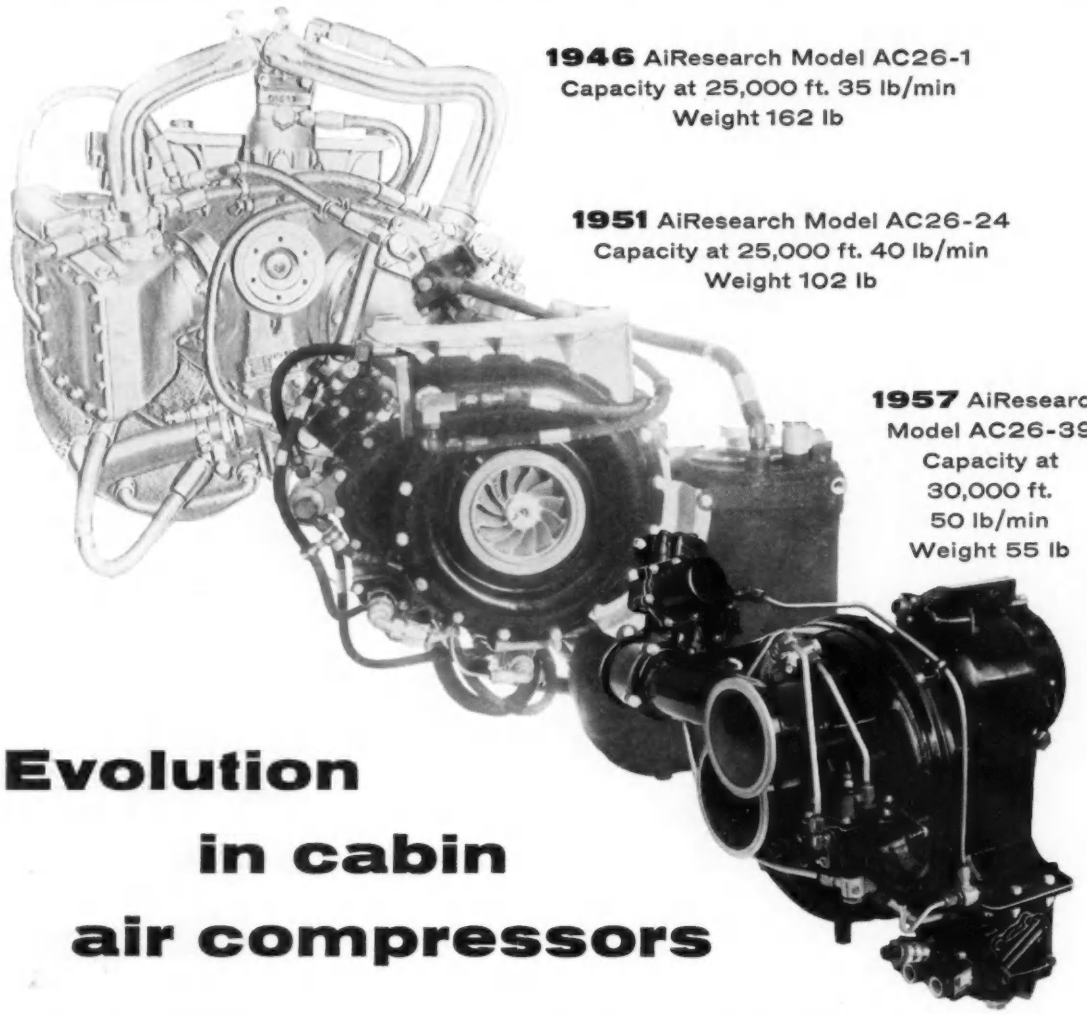

1946 AiResearch Model AC26-1
Capacity at 25,000 ft. 35 lb/min
Weight 162 lb

1951 AiResearch Model AC26-24
Capacity at 25,000 ft. 40 lb/min
Weight 102 lb

1957 AiResearch
Model AC26-39
Capacity at
30,000 ft.
50 lb/min
Weight 55 lb

Evolution in cabin air compressors

New AiResearch unit weighs one-third as much, increases performance by 43%

The performance demands on aircraft cabin air compressors are constantly increasing. Yet weight and space limitation on these pressurization components becomes even more critical. Basic design advancement is the only solution.

AiResearch has achieved this in its new, engine-driven compressor for turboprop aircraft. Compared to earlier models, it increases output by 43% while actually cutting weight to one-third. Dependability and durability are assured by the company's extensive experience in the production of all types of cabin air compressors, including units for the latest jet transports.

Superior performance is further assured by our unmatched experience in developing compatible systems. AiResearch has assumed complete system responsibility in the field of pressurization for many of America's finest present and projected airliners. We invite your inquiries.

Outstanding opportunities for qualified engineers are available now. Write for information.

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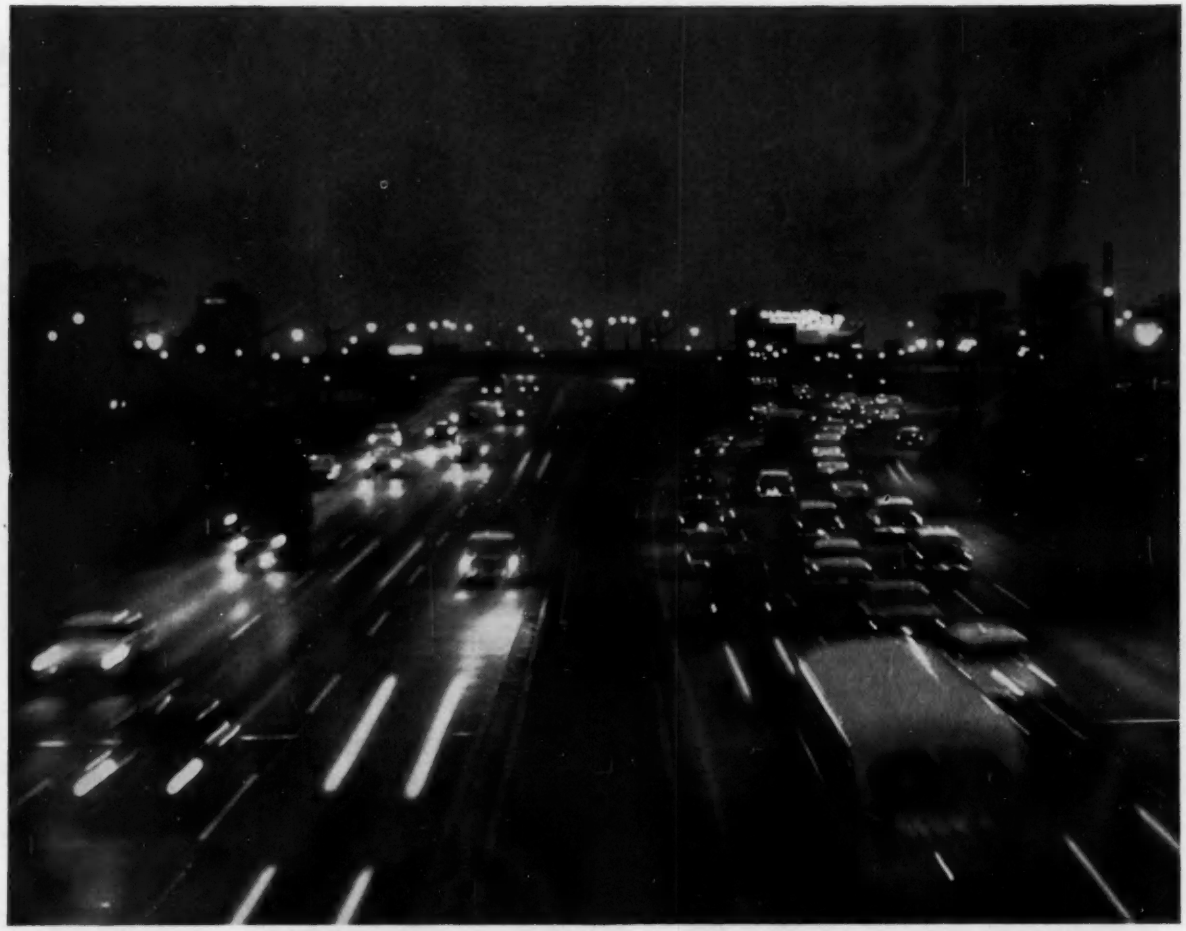
AiResearch Manufacturing Divisions

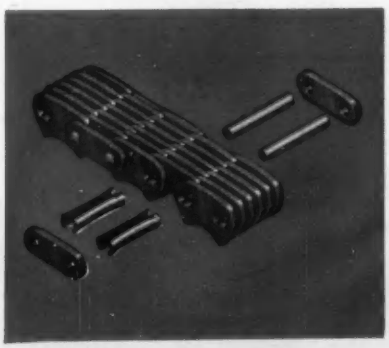
Los Angeles 45, California . . . Phoenix, Arizona

Designers and manufacturers of aircraft and missile systems and components: REFRIGERATION SYSTEMS • PNEUMATIC VALVES AND CONTROLS • TEMPERATURE CONTROL • CABIN AIR COMPRESSORS • TURBINE MOTORS • GAS TURBINE ENGINES • CABIN PRESSURE CONTROLS • HEAT TRANSFER EQUIPMENT • ELECTRO-MECHANICAL EQUIPMENT • ELECTRONIC COMPUTERS AND CONTROLS



More than 80,000,000 durable Morse Timing Chains have been used by the auto industry. Now specified as original equipment for 21 out of 23 passenger cars, Morse Timing Chains give car owners steady, reliable service—operate quietly and smoothly, with positive timing.

WHY 21 OUT OF 23 1957 CARS CHOOSE TIMING CHAINS BY MORSE



This new Morse Timing Chain, above, designed to meet the needs of higher horsepower 1957 cars, features spring-bushing joint construction for longer service, smoother and quieter operation. The new bushing cuts joint vibration by reducing tendency to "whip", provides for take-up of slack, and serves as a damping device to minimize noise. Ask for Catalog C60-51.

Chances are your new car will have a Morse Timing Chain. For sound reasons, too. Morse Timing Chains are precision-built—like fine watches—to give car owners longer service life and freedom from maintenance worries.

In Morse Timing Chains, sure dependability is built right in!

If you have a timing chain problem, original equipment or replacement, it will pay you to get in touch with Morse. For full information—and ready engineering help—phone, wire or write *MORSE CHAIN COMPANY, DETROIT, MICHIGAN; ITHACA, NEW YORK. Export Sales: Borg-Warner International, Chicago 3, Ill.*

SERVING THE AUTOMOTIVE INDUSTRY FOR OVER 55 YEARS

MORSE BW

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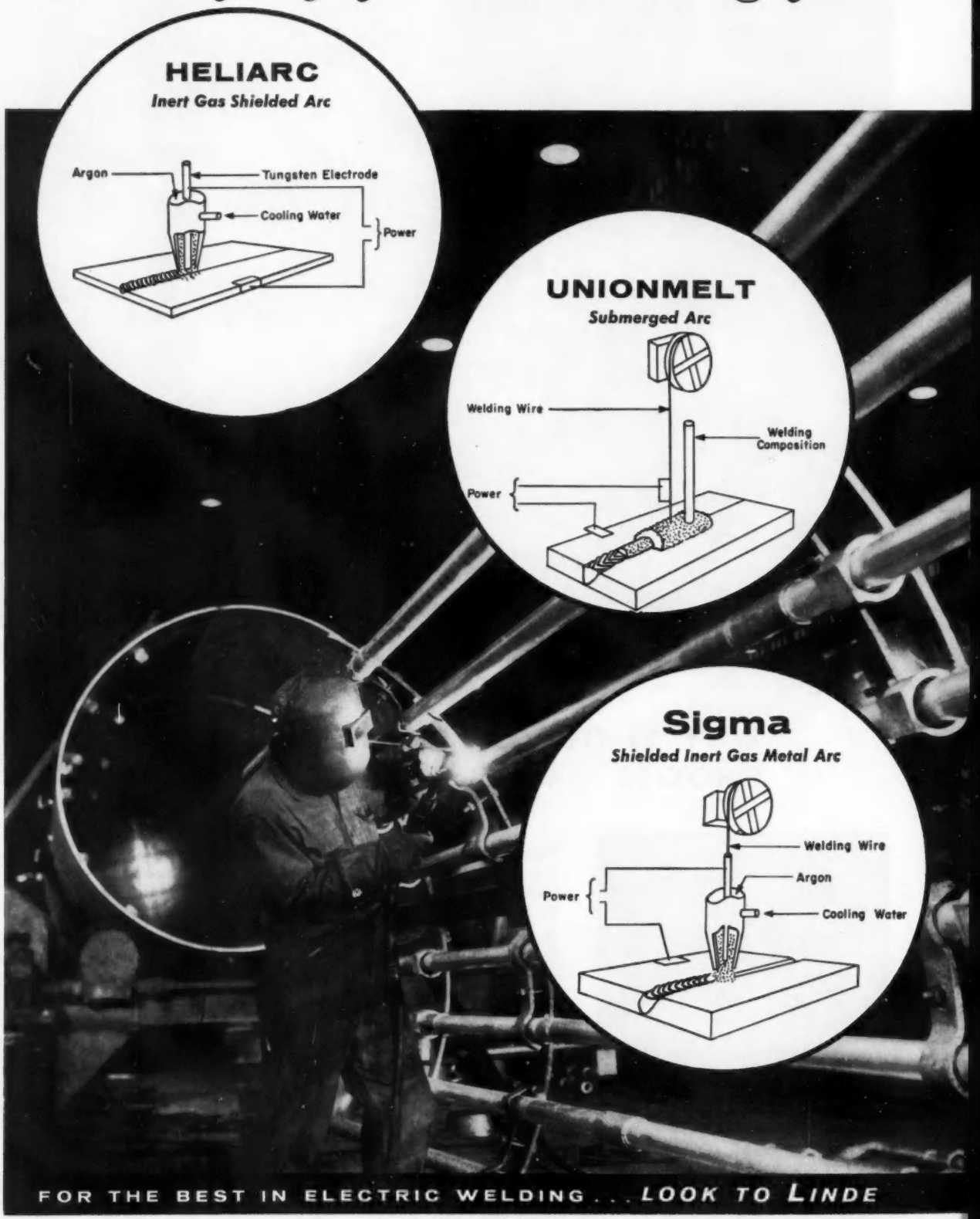
For any of your welding jobs



. . . LINDE can supply the *right method!*

Inert gas shielded arc welding—

HELIARC Apparatus for inert gas shielded arc welding, using a tungsten electrode and a shield of LINDE argon, is tops for joining hard-to-weld commercial metals. On stainless steel and aluminum, HELIARC Welding is fast and clean, producing high-quality welds that resist corrosion. HELIARC Welding eliminates costly grinding and finishing, making it a valuable method for quantity production of hard-to-weld metals.

Submerged arc welding—

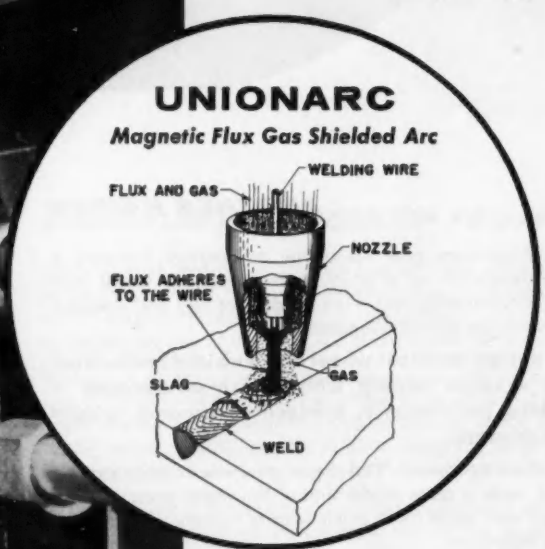
Shapes made of materials ranging from light gage to heavy plate, adaptable to mechanization, can be most economically joined by UNIONMELT Welding. It is used on low and medium carbon steels and alloy steels, including those containing chrome and/or nickel. UNIONMELT Welding is also used extensively for resurfacing metal, providing extra wear and corrosion resistance. UNIONMELT Welding is fast and inexpensive on production jobs.

Shielded inert gas metal arc welding—

One of the most versatile welding methods is Sigma Welding. LINDE's Sigma apparatus, using a shield of LINDE argon, is ideal for manual welding of commercial metals $\frac{1}{8}$ in. or more thick, and for automatic operation on lighter gage metals to .050 in. Highest quality welds can be made on aluminum thicker than $\frac{1}{8}$ in. at speeds up to 16 inches per minute. Build-up and surfacing jobs are also improved by using LINDE's Sigma welding method.

New! Magnetic flux gas shielded arc welding—

UNIONARC Welding, LINDE's most recent development in electric welding, is an extremely fast method for welding mild steel. This method employs a continuously-fed, bare steel wire electrode, magnetically coated with flux conveyed in a stream of carbon dioxide shielding gas. Manual welds can be made easily in any position—vertical, overhead, downhand—with no stops to change electrodes. The speed, versatility, and ease of operation of of UNIONARC Welding brings costs down 25% to 65% below those of manual covered electrode welding. Clean, smooth, high-quality welds are provided, even in the presence of moderate amounts of rust, scale, and moisture.



Engineers at LINDE have been designing, developing, and testing electric welding methods and apparatus for many years. Help on any welding method is yours for the asking. You can improve your work and cut production problems by taking advantage of LINDE's experience. For data on UNIONARC Welding or any other electric welding method, call the LINDE office nearest you.

LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

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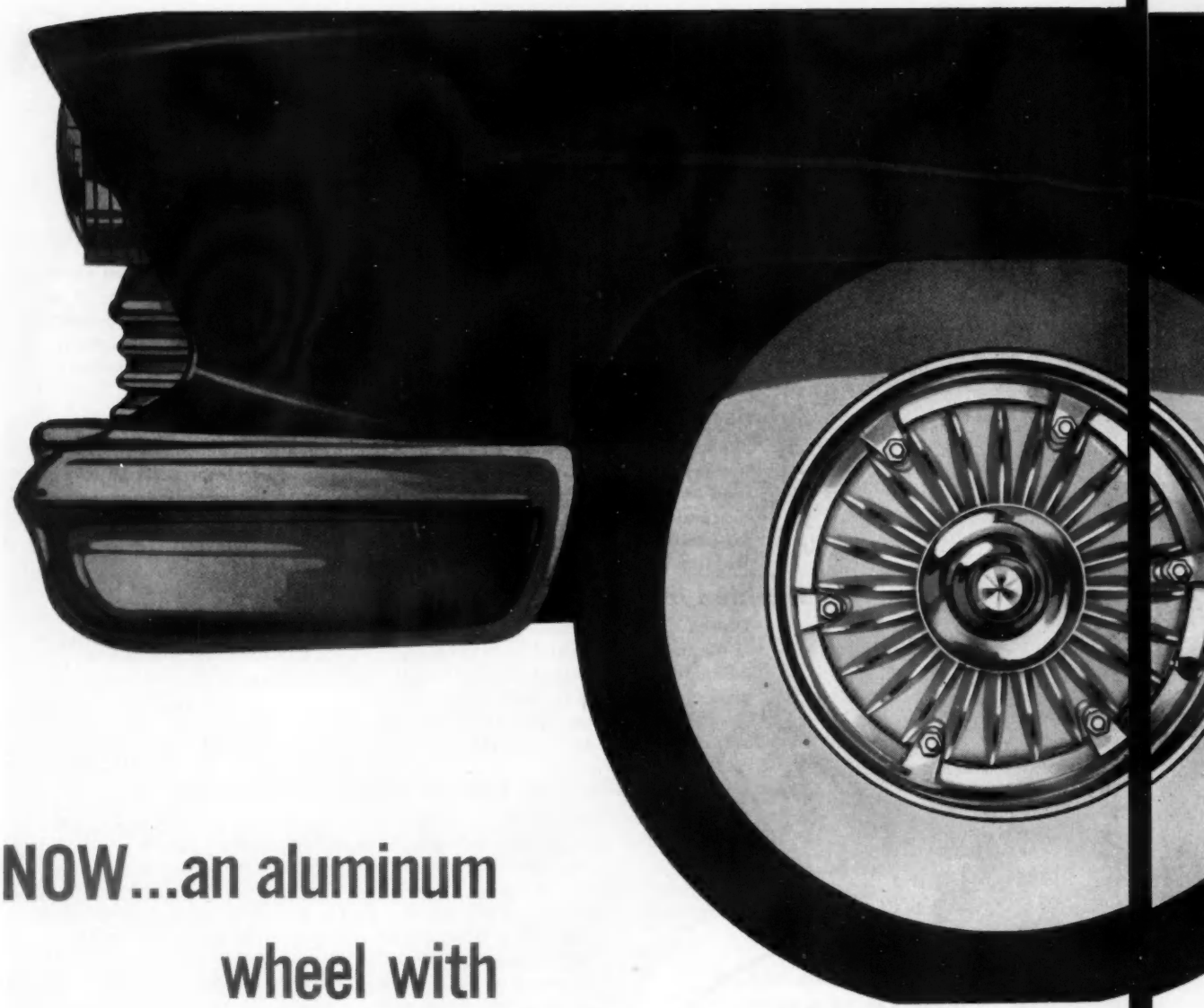


NOW...an aluminum wheel with integral hub and drum designed for casting

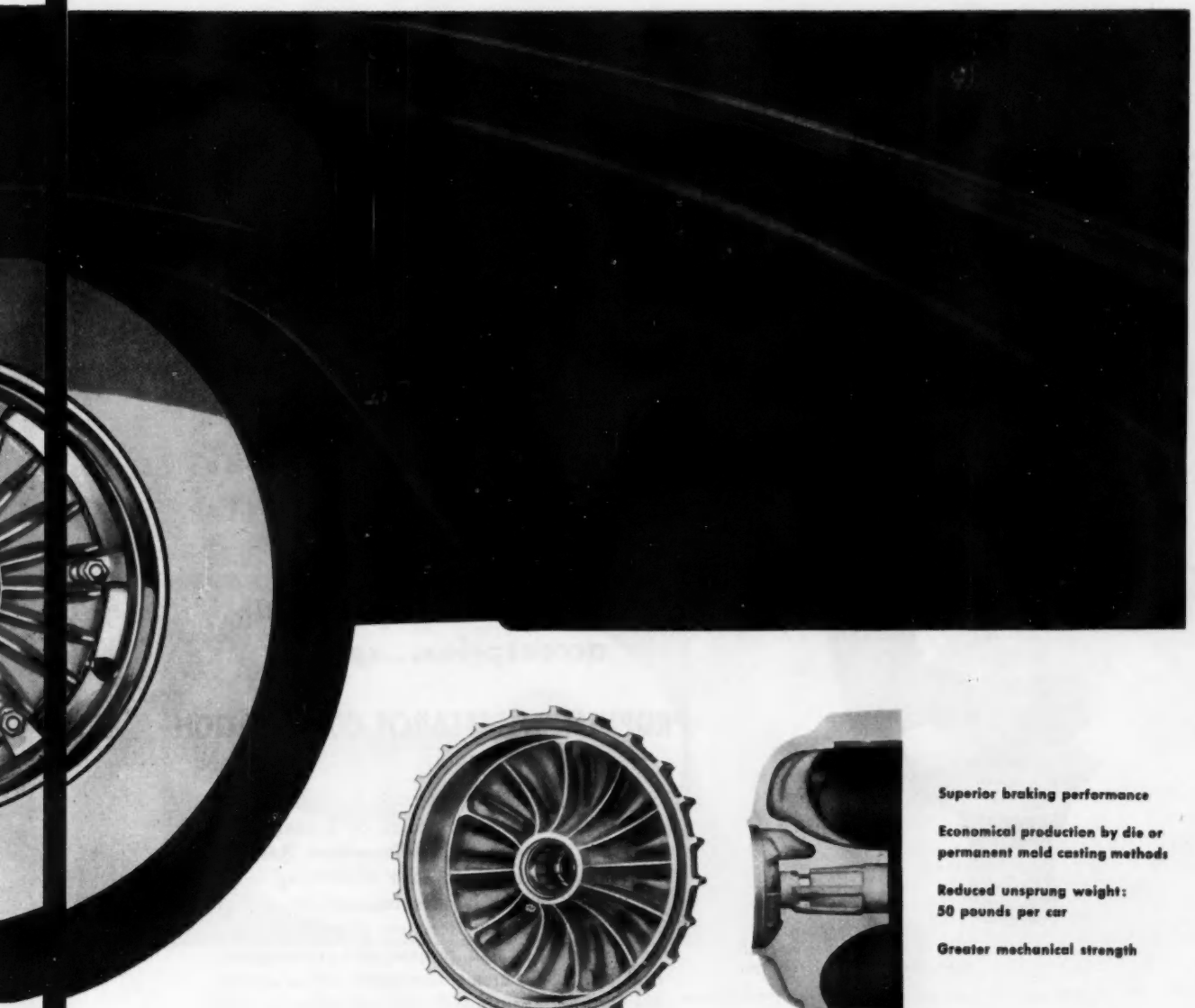
ANOTHER KAISER

Kaiser Aluminum now offers the automotive industry a unique design for an aluminum passenger car wheel that can be economically cast—the product of two and one-half years of design and development.

The design combines wheel disc, hub and brake drum into a single casting with unique advantages in braking performance, production economy, weight and strength:

Production economy: The die or permanent mold casting method renders mass production of the wheel economically practical and lends itself to an infinite variety of attractive styling variations.

Braking performance: Dynamic and brake dynamometer tests indicate that the performance of this aluminum wheel far surpasses accepted standards. Tests show substantially less brake fade—due to aluminum's high heat conductivity,



Superior braking performance

Economical production by die or permanent mold casting methods

Reduced unsprung weight: 50 pounds per car

Greater mechanical strength

ALUMINUM PARTNERSHIP PROJECT WITH THE AUTOMOTIVE INDUSTRY

direct flow of heat to cooling fins and virtually unrestricted passage of cooling air over heat-dissipating surfaces. The actual braking surface is a ferrous metal liner held in place or bonded by any of the accepted commercial methods.

Weight: A prototype wheel with rim weighs only 30 pounds as compared to 42.6 pounds for a steel wheel, hub and brake drum assembly. This saving—12.6 pounds or about 30 per cent—makes possible greatly reduced unsprung weight, improved riding characteristics, better over-all performance.

Strength: Design of the wheel combines wheel disc and hub for greatest strength at least weight, and at the same time exposes ample surface area for efficient air-cooling. The design also minimizes the contact area between the demountable rim and the aluminum casting; this restricts the direct heat flow to the rim, thereby increasing the tire life.

Kaiser Aluminum *does not* manufacture the cast aluminum wheel; but *does* work as idea partner to the automotive industry, helping introduce better parts at lower cost through developments in aluminum.

Our Automotive Development engineers are available to work with you on applications of the cast aluminum wheel . . . as well as to help you on other specific requirements and problems in aluminum alloy selection and fabrication.

For further information, call our Automotive Industry Division, TRinity 3-8000, Detroit. Kaiser Aluminum & Chemical Sales, Inc., 2214 Fisher Bldg., Detroit 2, Michigan.

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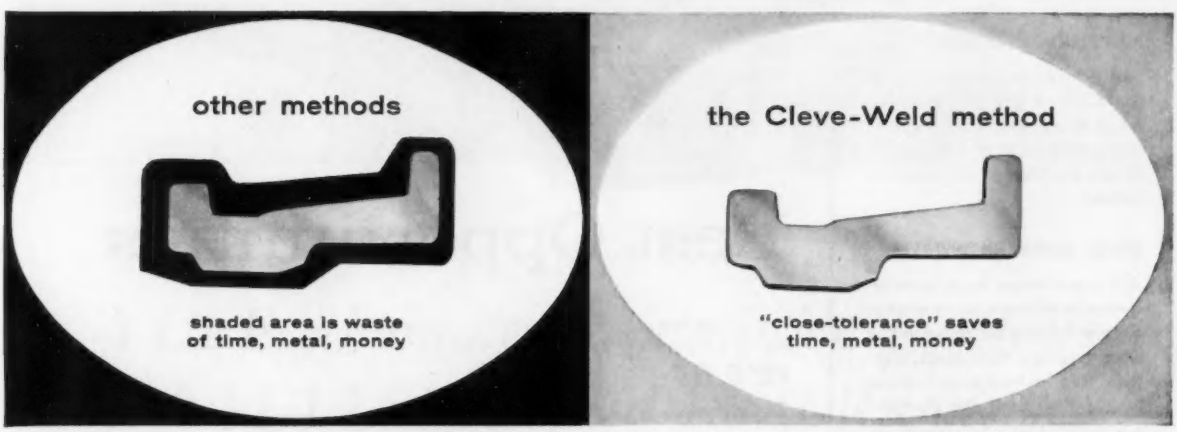
...with Cleve-Weld "close-tolerance" circular welded components!



When you specify bulky cast or forged parts, you pay for excess metal...then pay to shave it away! But every ounce of material on "close-tolerance" Cleve-Weld circular steel parts has a function. A minimum of finish machining gives you a component ready for the assembly line!

With Cleve-Weld components, you reduce waste costs up to 30% while you save on production time.

If your specs call for "wonder metals" like titanium, the material and machining time we can save you will probably pay for the whole Cleve-Weld part!

Over 45 years of welding specialization backs the Cleve-Weld Process. In fact, we've designed our own special machinery for roll-and-weld processes. That's why we can produce, in quantity, everything from simple bands to jet rings and complex shapes and cross sections. And we're right at home with practically any metal under the sun...from carbon steel to the latest aircraft alloys!

Your circular components can probably be produced through the Cleve-Weld Process! Find out how Cleve-Weld can cut costs and improve performance for your products...write, call or send drawings to Circular Welded Products Sales Department, at the address shown below!

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RIMS · RINGS · WELDMENTS

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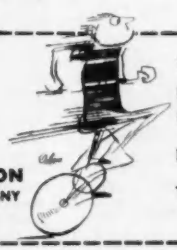

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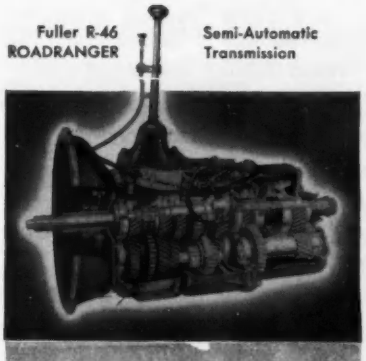
Semi-Automatic Transmission



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Says V. A. Martell, President of Yule Truck Lines, Inc., Milwaukee, Wisconsin: "Fuller ROADRANGERS have eliminated all our transmission problems. We get the kind of gearing we need to take us through any kind of traffic and road condition. After continuous testing under every conceivable condition, the Fuller 8-speed semi-automatic ROADRANGER Transmission thoroughly proved itself. Our drivers say: 'This is it!' and they wouldn't have anything else."

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Yule's latest fleet additions include 10 International CO-205 Tractors with RD-450 Engines, and 5 International R-195 Tractors with RD-406 Engines . . . all equipped with Fuller 8-speed semi-automatic ROADRANGER Transmissions.

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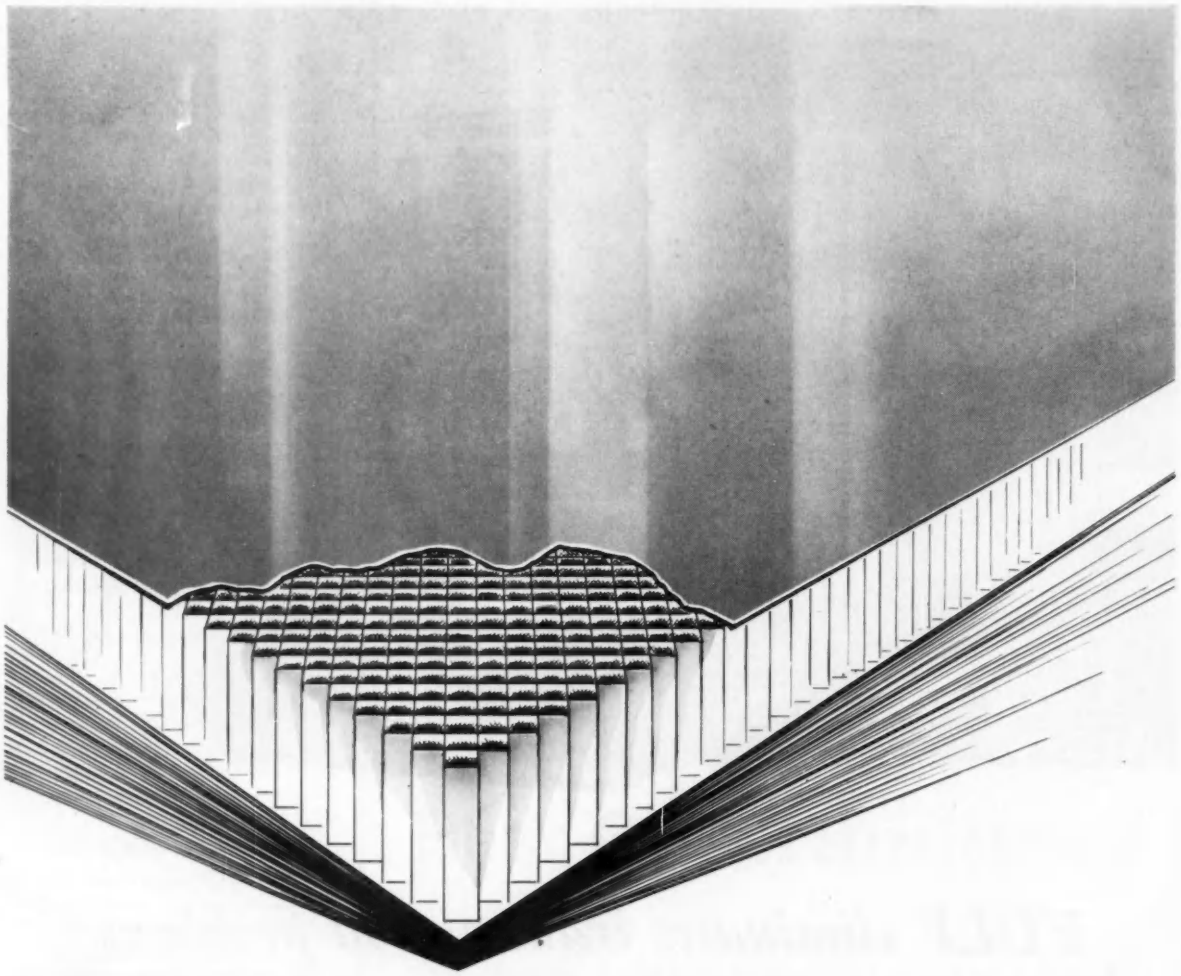
For complete details on Fuller ROADRANGERS, see your truck manufacturer or truck dealer now!



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Readily available in non-staining grades, Enjay Butyl rubber can be compounded into white and light-colored parts that combine beauty with top-notch performance. Low in cost, it out-performs and out-lasts all other rubbers formerly used, and may well be able to *cut costs* and *improve performance* in *your* product. For further information, and for expert technical assistance, contact the Enjay Company.

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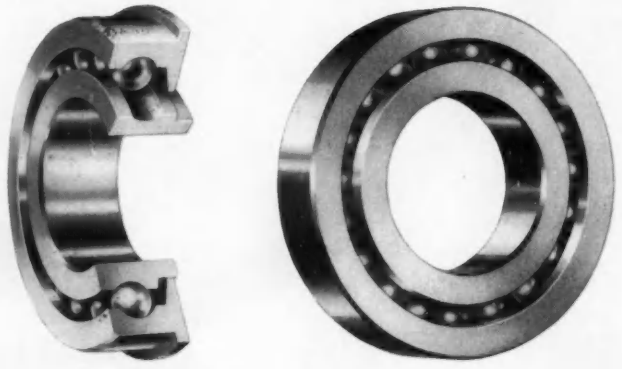
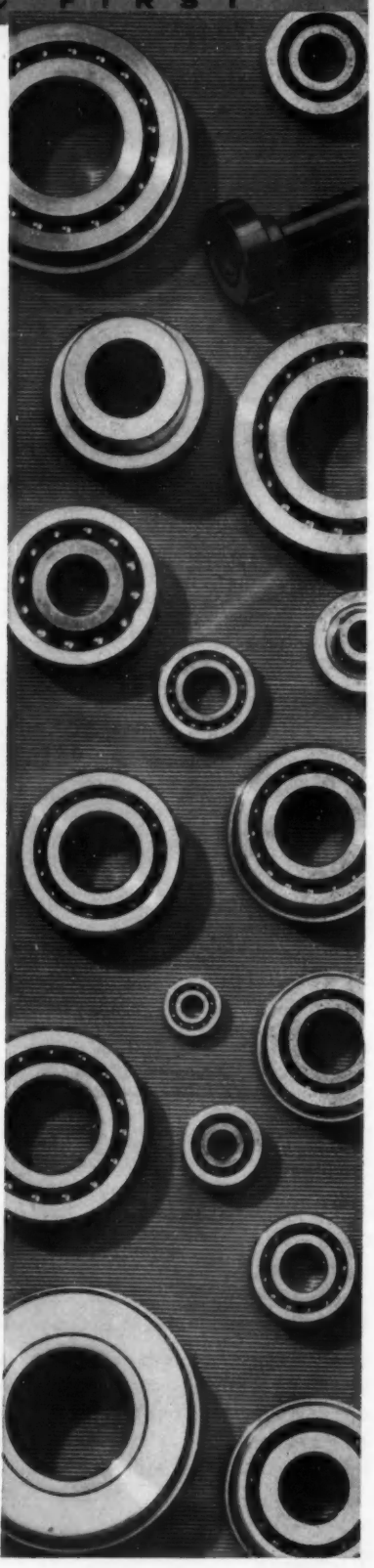
without insertion grooves or inserts





A most unusual, NEW concept in ball bearing design . . .

Here is a commercial ball bearing with solid, unbroken machined inner and outer raceways, yet with a full complement of balls.

It has deep, burnished ball grooves that are deep carburized and hardened. The revolutionary and radically new method of manufacture permits assembly of these ball bearings in a way that borders on the mysterious and challenges the imagination.

Radial and axial load capacities are increased because of the raceway construction, resulting in longer bearing life.

Unibal Ball Bearings can be furnished in single row, double row and flanged types; to close tolerances on bore and outside diameter; and with controlled radial and axial play.

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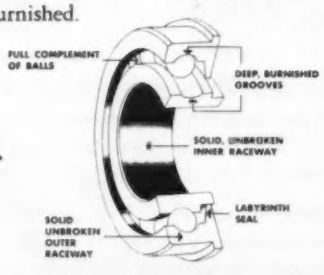

Special circular with load ratings and dimensions on the new Unibal Ball Bearings is available.

HEIM also makes the Unibal Spherical Bearing Rod End. Send for complete catalog of all Heim bearings. Write direct or see your local bearing distributor.

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Success of X-10 Test Missile program steps up systems engineering work on

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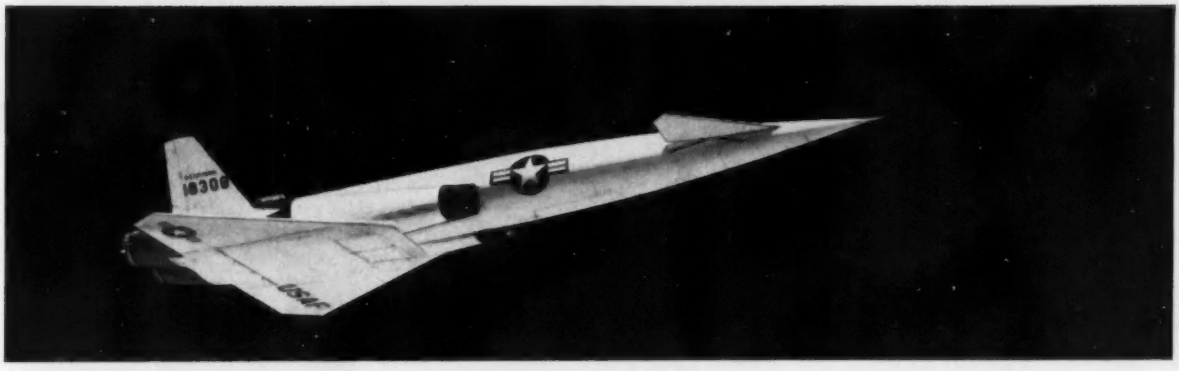
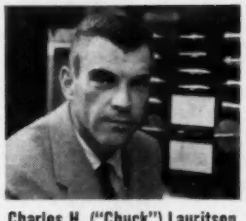


The pace is quickening, as we gather forces for the climactic effort on the Navaho. If you like excitement in your engineering—this is it! You can decide now, and still get in on the work coming up at North American's Missile Development Division. It's going to be an assignment you'll be glad you took part in for years ahead.

James A. Trapp, 33, has been with NAA's Missile Division since 1952. He holds both BS and MS in Electrical Engineering. Now Group Leader, Auto Checkout Systems, he supervises development of digital techniques. Hi-fi fan and fisherman, this Oklahoman now lives in Long Beach with his wife and 2 California tots.

The Navaho is a project with the toughest kind of painstaking engineering behind it. It's been several years now since this organization set out to deliver to the Air Force a complete strategic weapon system. On the way we opened up and proved out more workable missile information than any other source: structures, guidance, propulsion, armament, ground handling, launching—the works. Now you can join us... get in at the forefront of missile technology. If you do, you're going to build a weapon with the world's most advanced self-contained guidance system ... driven at supersonic speeds by both rocket and ram-jet engines . . . and packing an accuracy/payload punch that's unbeatable in the foreseeable future.



Charles H. ("Chuck") Lauritsen, 31-year old ex-Navy man, hails originally from Beatrice, Neb. Study at Chicago, Northwestern and Michigan gave him his BS and MS, Aero Eng. Starting in 1947, he rose thru Group Leader to Section Head of Project Aerodynamics, responsible for aerodynamic analysis on all Division contracts.

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NORTH AMERICAN AVIATION, INC.

Mr. R. L. Cunningham, Engineering Personnel Manager, Dept. SE7
12214 Lakewood Boulevard, Downey, Calif.

Dear Mr. Cunningham:

Please send me career information on Missile Development Division. I am interested in the following fields (check one or more).

Systems ☐ Guidance ☐ Structures ☐ Propulsion ☐ Armament ☐ Check Out ☐ Ground Handling ☐ Aerodynamics ☐ Thermodynamics ☐ Dynamics ☐

Name_____ Home Address_____

Degree(s)_____ Home Phone_____

Experience_____

New Thompson automatic Truck Retarder insures extra safety!

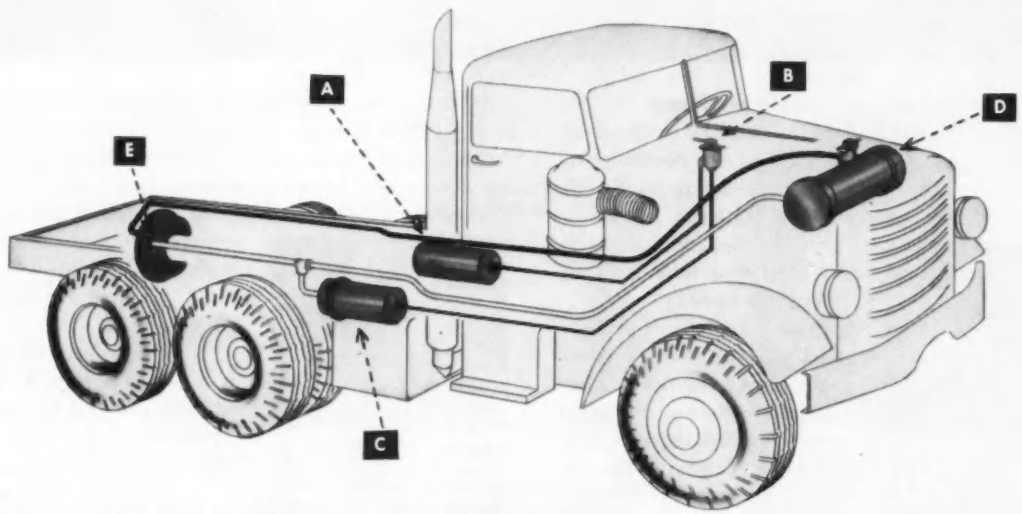
Radical new development means greater driver-control on highways, hills and dangerous curves... plus longer truck life

WITH today's higher highway cruising speeds and heavier payloads, Thompson's revolutionary new hydraulic Truck Retarder ... light, compact and powerful ... now provides an *extra* safety margin for trucks and tractors of *any* size.

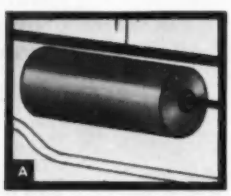
The Thompson Truck Retarder works COMPLETELY INDEPENDENTLY of the vehicle's service and emergency brakes!

The efficiency of a more dependable braking system ... due to the use of this Thompson-developed *auxiliary* braking system ... means less costly wear and tear on the service *and* emergency brakes. This results in fewer road breakdowns ... less time in repair shops ... and lower maintenance costs and longer truck life for truck and fleet owners.

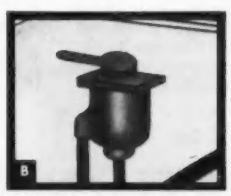
For complete technical information write, wire or phone Michigan Division, Thompson Products, Inc., 34201 Van Dyke, Warren, Michigan.



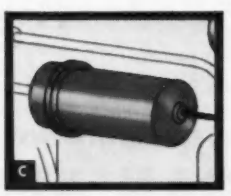
How the Thompson truck retarder works



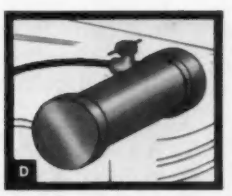
REGULAR AIR SYSTEM supplied on the vehicle also provides the air used by the auxiliary braking system. As an additional safety feature a compressed air reservoir can be applied for emergency use in case the regular air system fails.



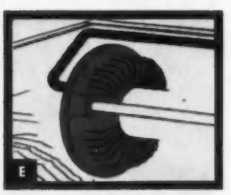
CONTROL VALVE, located in the cab and operated by hand, supplies air from the service brake system to the loading cylinder.



LOADING CYLINDER supplies retarder fluid which is forced under varying air pressures to the retarder. When the retarder is not required, fluid is pumped back into loading cylinder.



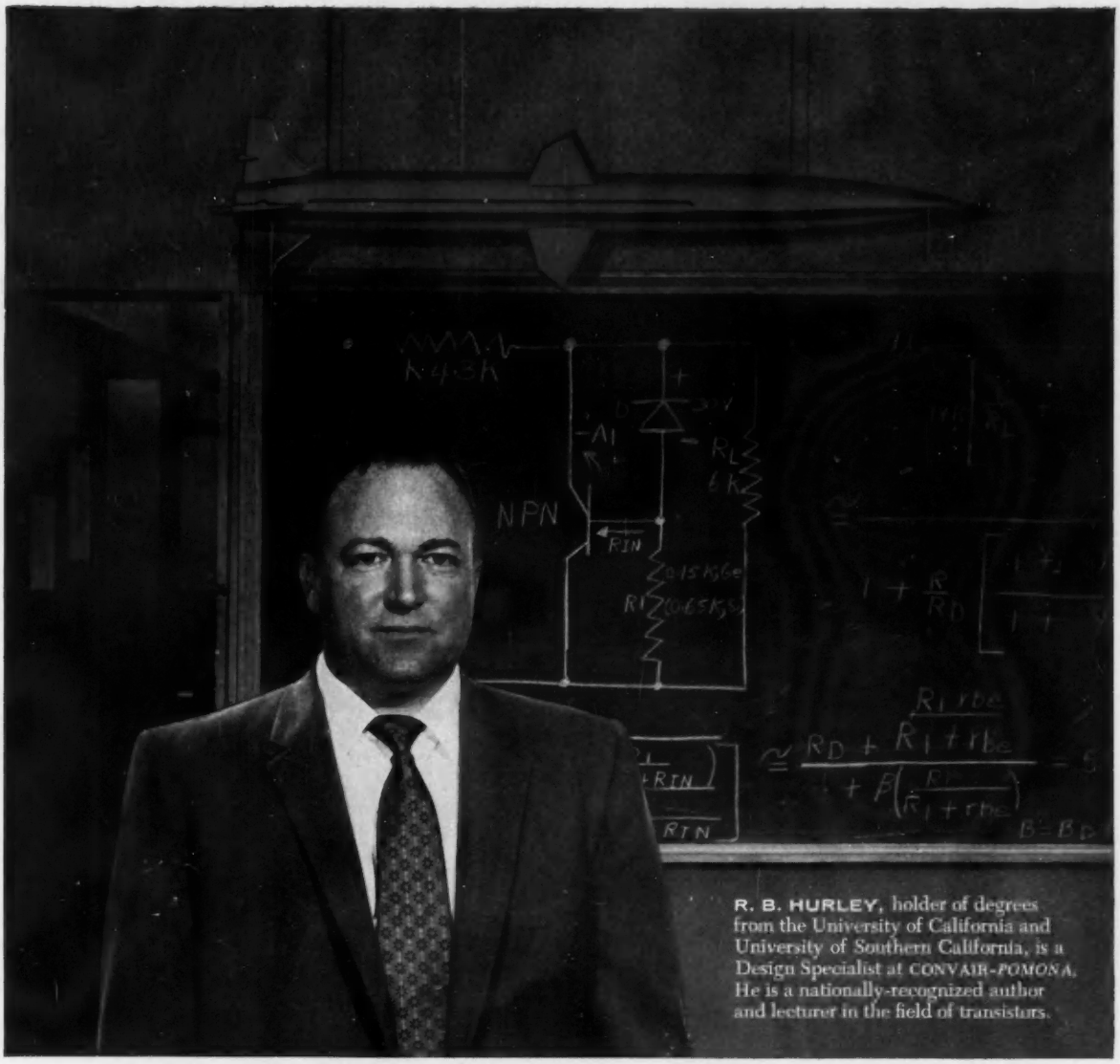
HEAT EXCHANGER, located within the engine compartment, dissipates the heat through the vehicle's cooling system.



THOMPSON RETARDER—"heart" of the system. Fluid from the loading cylinder strikes against the revolving vanes of the rotor, slowing the vehicle without use of service brakes, leaving them cool for maximum efficiency.

You can count on TP **Thompson Products**

MICHIGAN DIVISION: WARREN AND PORTLAND



R. B. HURLEY, holder of degrees from the University of California and University of Southern California, is a Design Specialist at CONVAIR-*POMONA*. He is a nationally-recognized author and lecturer in the field of transistors.

"Engineers—here's how we're taking part in the electronics revolution toward solid state devices"

"Here at CONVAIR-*POMONA*, we are constantly studying ways to apply the new miniature solid state electronic devices: the diode, rectifier and transistor. So new is this semiconductor infant, and so vast its future – both for the military and industry – that our teams of electronics engineers actually 'go to school' under some of the foremost experts in the field.

"As the *first* fully-integrated missile plant in the U.S., CONVAIR-*POMONA* designs and builds the Navy's TERRIER supersonic missile. And, realizing the potential value of solid state devices in meeting the critical requirements of such airborne missiles, we initiated a 'transistor program' early in 1953. This program has multiplied many times to become one of the most important in the industry.

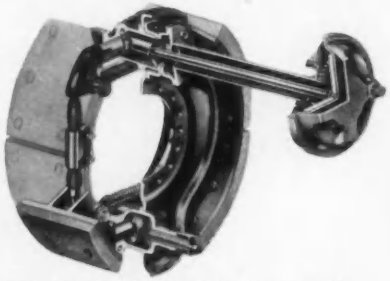
"You, as an engineer, can appreciate the tremendous expansion that will come in the application of solid state electronic devices in the next few years. And you can readily understand the advantages of studying and working with these devices, guided by the advanced thinking you will find at CONVAIR-*POMONA*.

"You'll like the atmosphere here, where you see and feel accomplishment. And you will enjoy living in Southern California's beautiful Pomona valley. For greater career opportunity – *for your future's sake* – send for more information about CONVAIR-*POMONA today!* Write to: Engineering Personnel, Dept. 3-B

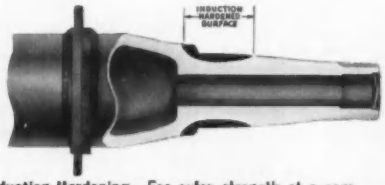
CONVAIR
POMONA
POMONA • CALIFORNIA
CONVAIR IS A DIVISION OF GENERAL DYNAMICS CORPORATION

A tough answer to rising costs . . .

CLARK tubular Trailer Axle!



Advanced Brake Design—Both shoes are free-floating and self-centering, assuring full lining contact and compensation for wear. Both shoes are fully energized in forward direction and one or both shoes fully energized in reverse.



Induction Hardening—For extra strength at a common area of failure, the inner wheel bearing surfaces are induction hardened, increasing the fatigue factor by 400 per cent.

- **light, rugged alloy steel**
- **induction hardened bearing seat for increased strength**
- **revolutionary brakes—more efficient, lighter, fewer parts**

Designed to *carry loads effectively* and to *stop loads positively, safely*, this Clark tubular axle is your smart, tough answer to climbing costs of operation.

- **New "High" in braking efficiency**—of revolutionary design the Clark MC (Maximum Capacity) Brake increases stopping action, and makes brakes last longer. No cam shafts, no slack adjusters—fewer parts, *less weight.*
- **Interchangeable parts cut inventory**—Two sizes of axle center *use same wheel and brake parts*—and these parts are also *interchangeable with other makes of axle.* Brake linings and shoes easy to remove—simplest possible design for low-cost maintenance.

As a sensible, practical step toward substantial operating savings, send for a helpful bulletin—the coupon gets it promptly.

CLARK® EQUIPMENT

CLARK EQUIPMENT COMPANY • AXLE DIVISION, Buchanan 5, Michigan

Please send further information on new Clark Trailer Axle.

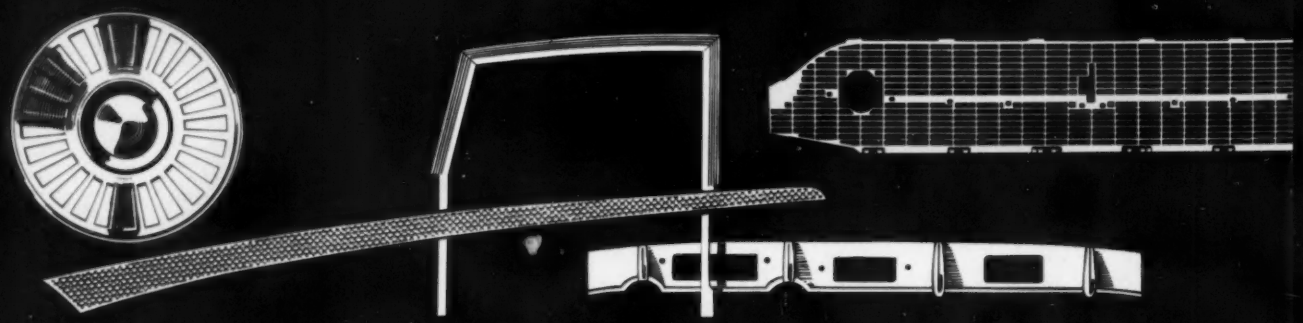
NAME_____ POSITION_____

FIRM_____ ADDRESS_____

CITY_____ STATE_____

cannot rust! They
save weight, add beauty

are made with
REYNOLDS ALUMINUM



ALUMINUM BUMPERS, durability proved on cross-country buses for years, are getting close attention today for passenger car applications. Why? Because aluminum bumpers last longer—will not rust. Because they cut weight—give brakes less load to stop. Because they can be clear or color anodized with the "look of sterling" or the "gleam of gold" or other colors. Because they cut tooling costs—can be fabricated economically. For example, in an aluminum bumper extrusion, reinforcing members can be designed integral with the bumper itself. And it is also easy to extrude a groove for inserting a rubber or plastic bumper face.

Aluminum bumpers are only one application where the automotive industry can cut costs, reduce weight, increase beauty by using aluminum. Grilles, instrument panels, wheel covers, emblems—all types of decorative trim inside and out—as well as countless motor parts, are proved applications for this modern metal. And for lighter, brighter tomorrows, aluminum roof panels, rear decks and hoods are already stimulating the imagination of the forward looking automotive industry.

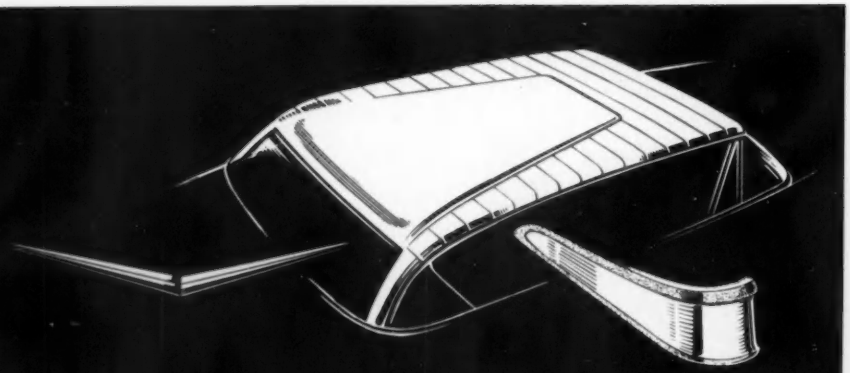
For aluminum mill products or for fabricated aluminum parts and trim, Reynolds Aluminum Specialists will be glad to work with you to help you get the very most from the aluminum you use. For details, call the Reynolds Office listed under "Aluminum" in your classified telephone directory. Or write *Reynolds Metals Company, Fisher Building, Detroit 2, Michigan* or *P.O. Box 1800-MV, Louisville 1, Kentucky.*

NOTE: Before you buy any part—have it priced in aluminum. Basic material costs do not determine part costs. New techniques and processes—applicable only to aluminum—can give you a better product at a lower *final cost.*

See "CIRCUS BOY", Reynolds dramatic series, Sundays on NBC-TV

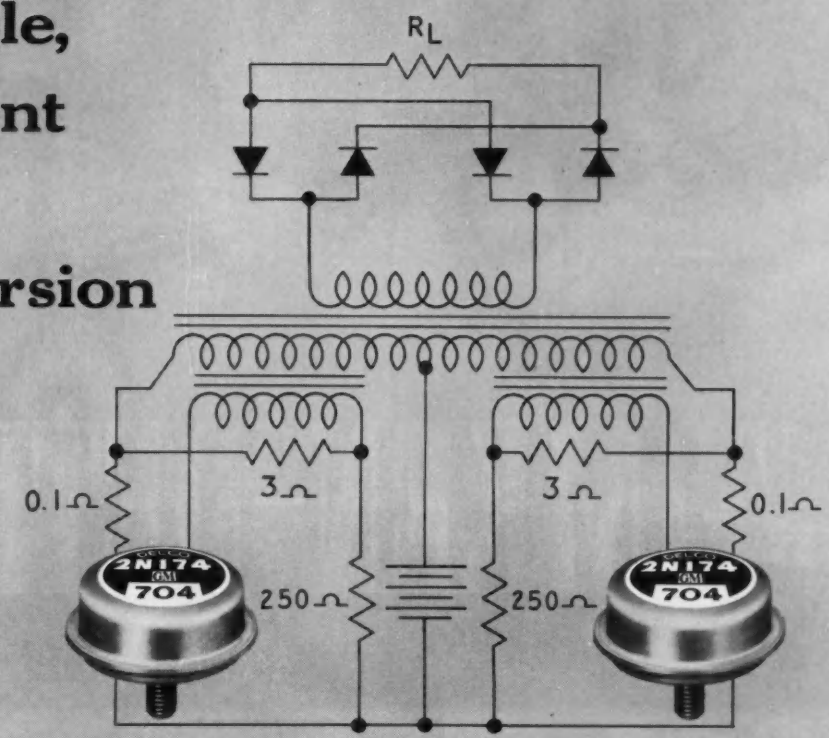
Reynolds Aluminum

THE METAL FOR AUTOMATION



The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

Reliable, Efficient DC Conversion



Industry's Highest Power Transistors

Low saturation voltage of Delco Radio 2N173 and 2N174 opens new opportunities for converter economy, efficiency and reliability

The excellent electrical characteristics of Delco High Power transistors permit the conversion of *low* DC voltage to *higher* DC voltage—with a high degree of efficiency—in a wide range of applications. This proved performance offers greater reliability than will be found in corresponding vibrator circuits.

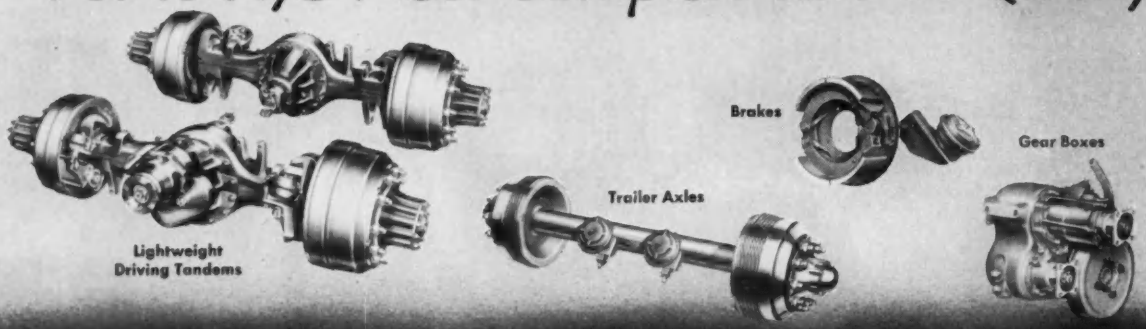
The low saturation voltage of Delco 2N173 and 2N174 transistors also reduces their internal power dissipation in conversion applications to an insignificant degree so that little self-heating is apparent. The result is an overall economy which permits converters of smaller size . . . important in many applications.

TYPICAL CHARACTERISTICS

	2N173	2N174
Properties (25°C)	12 Volts	28 Volts
Maximum current	12	12
Maximum collector voltage	60	80
Saturation voltage (12 amp.)	0.7	0.7
Power gain (Class A, 10 watts)	38	38
Alpha cutoff frequency	0.4	0.4
Power dissipation	55	55
Thermal gradient from junction to mounting base	1.2°	1.2°
Distortion (Class A, 10 watts)	5%	5%

DELCO RADIO DIVISION OF GENERAL MOTORS KOKOMO, INDIANA

For Today's Most Complete Line of Quality



SPECIFY... TIMKEN-DETROIT®

Whatever your requirements for highway or off-the-road-equipment... Timken-Detroit offers you a full line of torture-tested axles and brakes, both proven by almost 50 years of field testing and laboratory research!

Timken-Detroit manufactures today's most complete line of driving, trailer and front axles, plus brakes and gear boxes . . . with a full range of capacities in each product line.

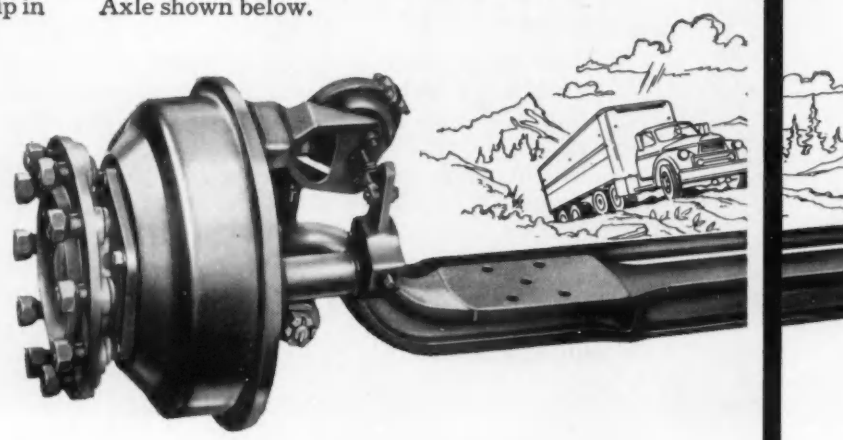
As a prime supplier to this nation's automotive industry for nearly 50 years—Timken-Detroit has learned the exacting needs of the trucking industry. The result: TDA® Axles and Brakes mean leadership in quality, service, safety and dependability.

Today we are manufacturing the industry's most complete line of front axles . . . ranging in capacity from light commercial vehicles to the heaviest off-highway applications.

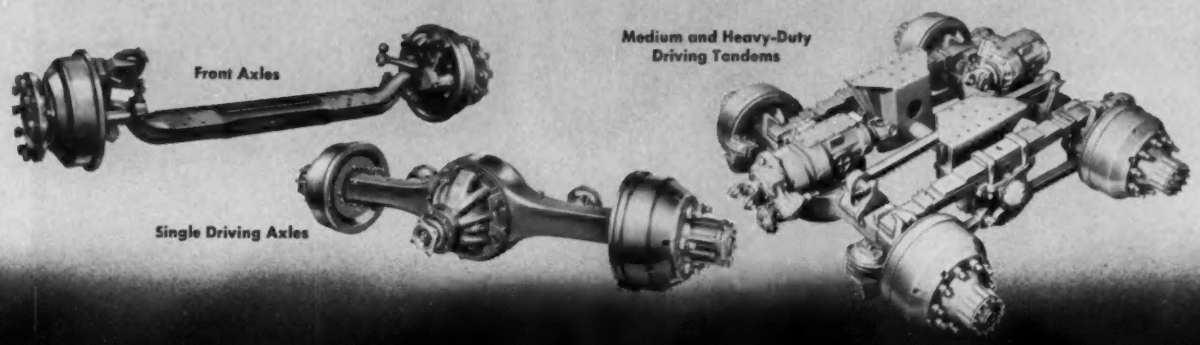
An example of the engineering features and superior quality built into every Timken-Detroit product is the F-900 Front Axle shown below.

Plants at: Detroit, Michigan • Oshkosh, Wisconsin
Utica, New York • Ashtabula, Kenton and Newark, Ohio
New Castle, Pennsylvania

TIMKEN Detroit AXLES
TIMKEN-DETROIT AXLE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
DETROIT 32, MICHIGAN
Accepted T D A Standard
WHERE MADE REGISTERED



Axles and Brakes for Commercial Vehicles



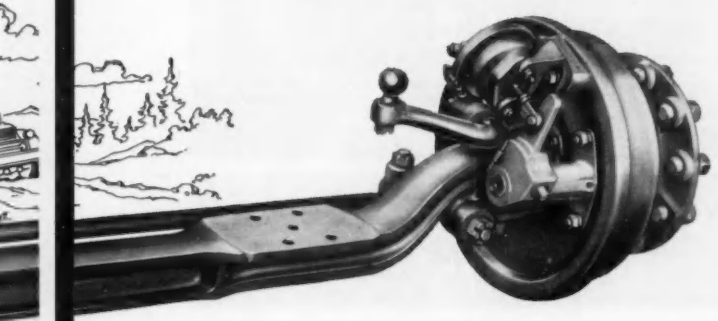
Products of

Rockwell Spring and Axle Co.

TIMKEN-DETROIT FRONT AXLES OFFER YOU GREATER STABILITY, SAFETY AND SERVICE!

You get better vehicle performance—under all conditions—with the F-900 Series Front Axles. Superior Timken-Detroit design and construction features give you front end stability—maximum strength and balance.

These improved Front Axles reduce driver fatigue . . . make steering easier . . . hold the driving path better . . . offer greater maneuverability . . . and contribute to increased vehicle life and superior performance.



Forged Axle Centers of high carbon steel are specially hardened for greater strength. The unique "Equalized-I" design between the spring pads provides uniform resistance to both horizontal and vertical forces.

Forged Knuckles of Alloy Steel are hardened for best metallurgical characteristics . . . are of improved design with large size spindles. A generous fillet where the spindle joins the knuckle body gives additional stiffness. These design features along with shot peening assure utmost strength.

Forged Steering and Tie Rod Arms are also of alloy steel and hardened. Stub arm design with carefully proportioned sections give these arms extra stamina and rigidity.

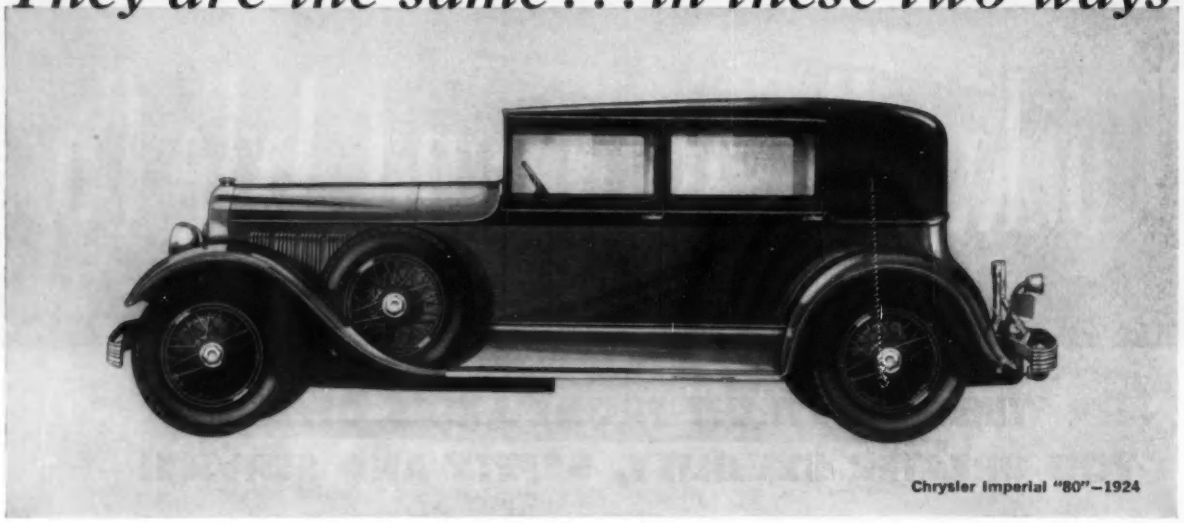
True Sphere Ball Studs in steering and tie rod arms have generous radii for maximum strength, and are induction hardened for long wear.

©1957, RS&A Company

WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSSES AND TRAILERS

Chance Vought F8U-1 Crusader

They are the same . . . in these two ways



Chrysler Imperial "80"—1924

. . . engineering leadership and filtration by Purolator!

Thirty-four years ago, that Chrysler came off the assembly line equipped with something entirely new: an oil filter. By 1956 when the Chance Vought F8U-1 Crusader shattered the national speed record, filters were accepted as basic components on all automobiles and aircraft. Both events were milestones — both vehicles were protected by Purolator.

The 1924 Chrysler seems a relic of another age, while the Crusader is as new as tomorrow. But the concept that got its start with the Chrysler has become fundamental everywhere . . . any fluid — be it air, fuel, lube oil, hydraulic fluid or anything else—which is vital to the proper operation of any aircraft, automobile or machine, must be filtered to be kept free of contamination.

Purolator makes filters for every fluid known to man—for use in any conceivable application. The unique background of specialized know-how enables them to produce the best possible filters for the specific needs of the automotive industry — no matter what they are or when they arise.

Filtration for Every Known Fluid

PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

Safety
Comfort
Economy

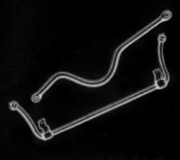
MONROE

The Greatest name in Ride Control

MONRO-MATIC SHOCK ABSORBERS — Standard on more makes of cars than any other brand.

MONROE AIR-O-STEER Power steering for air-equipped trucks, buses. Installed in 2 hours.

DIRECT ACTION POWER STEERING — The only truly direct-action Power Steering units available.



MONROE SWAY BARS— Specified as standard equipment on 15 makes of passenger cars.

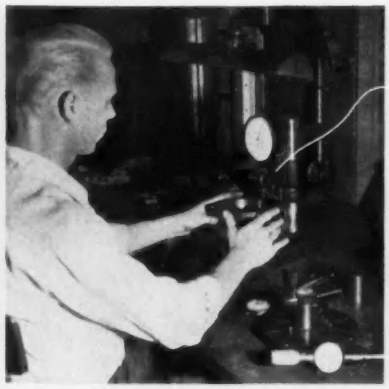
E-Z RIDE SEATS—Standard on more tractors than all other seats of this type combined.

MOLDED RUBBER PRODUCTS — Precision-built for all automotive and industrial applications.

MONROE AUTO EQUIPMENT COMPANY

Monroe, Michigan—World's Largest Maker of Ride Control Products

Accurate machining assures the smooth, cool operation of the Wagner Rotary Air Compressor. Close dimensions on all planes of the rotor eliminate vibration . . . permit compressor blades to function smoothly at high speeds



Accurate machining and gauge testing of the stator, as well as the rotor, also contributes to the rotary compressor's ability to operate for long periods of time without developing leaks or losing efficiency.

Compressor shafts are given the "cold box" treatment. When exposed to very low temperatures, the shaft diameter contracts. This altered shaft diameter allows proper insertion into a heated rotor to form a strong, composite unit.

Compressor rotors are subjected to high oven temperatures to expand rotor diameters. Shafts and rotors joined together under these extreme conditions resume their original relative size to create an extra strong assembly.

Assembled rotary compressors are hooked up to air lines and operating air pressure is applied for leakage tests. While holding pressure, entire compressor is submerged to determine whether any air is escaping.

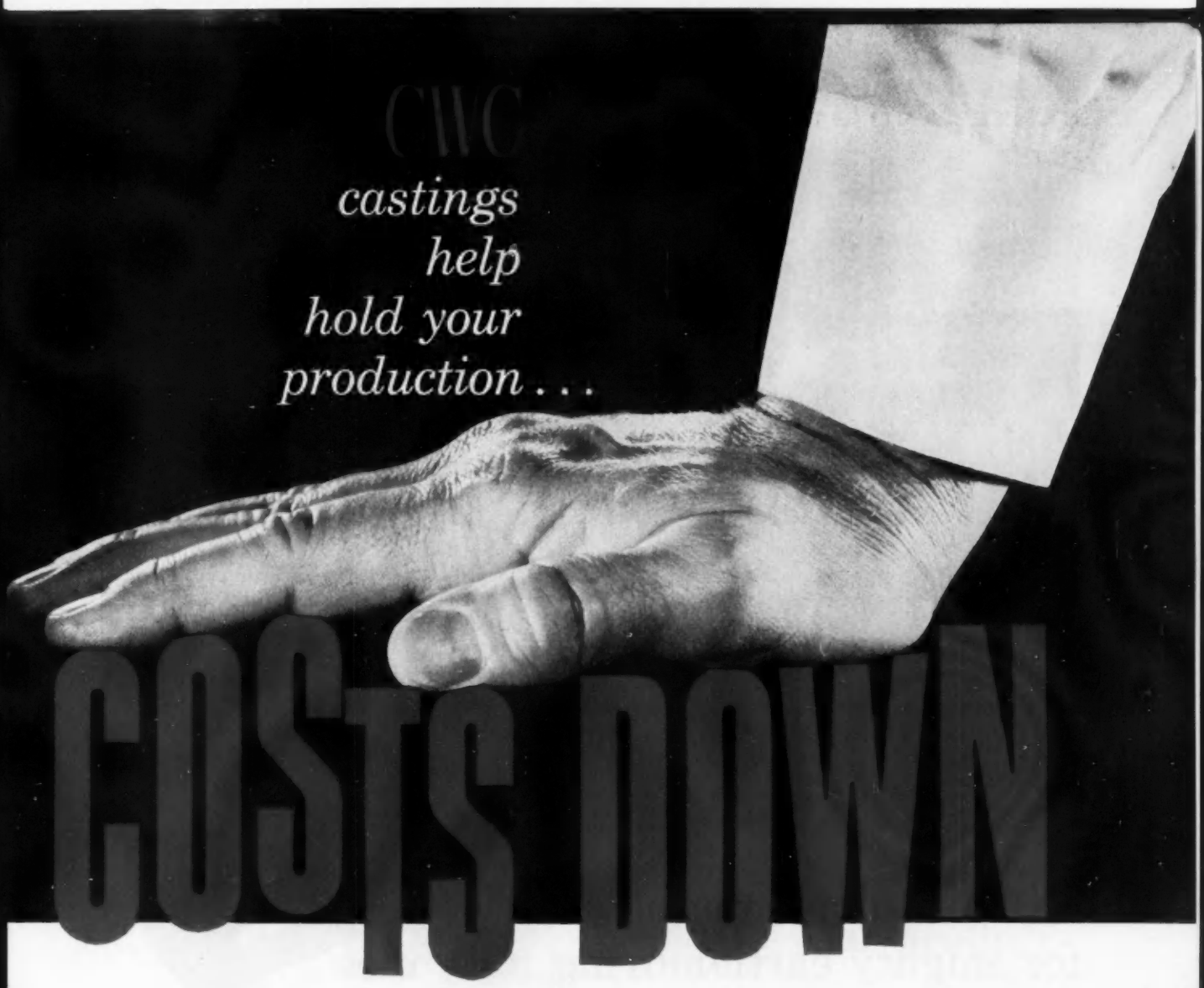
Every Wagner Rotary Air Compressor is given a rigorous "run-in" test to determine its resistance to overheating and its overall performance. Running temperatures, vibration, noise and air output are carefully noted and analyzed.

Rigid Quality Control assures uniform, safe performance and efficiency of all WAGNER ROTARY AIR COMPRESSORS

Wagner Rotary Air Compressors set exceptional records of safe performance, dependability, and air brake operating economy because of Wagner's "Quality Control" manufacturing program. Every Wagner Compressor must pass rigid inspection and tests before being released for shipment. That's why every user of a Wagner Rotary Air Compressor can rely on an adequate supply of air pressure at all times, fast air recovery, long service life, and *safer* brakes. The vehicles you manufacture will be safer if they are equipped with Wagner Air Brake Systems—supplied with Wagner Rotary Air Compressors. Complete details on Wagner Air Brake Systems, Rotary Air Compressors, and other Wagner Air Brake Components are contained in Catalog KU-201. Write for your file copy today.

Wagner Electric Corporation
6378 PLYMOUTH AVENUE, ST. LOUIS 14, MO., U. S. A.

LOCKHEED HYDRAULIC BRAKE PARTS and FLUID • NoRoL • CoMaX BRAKE LINING • AIR BRAKES • AIR HORNS • TACHOGRAPHS • ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES



campbell
wyant and
cannon

FOUNDRY COMPANY

Division of Textron Inc.

Muskegon, Michigan

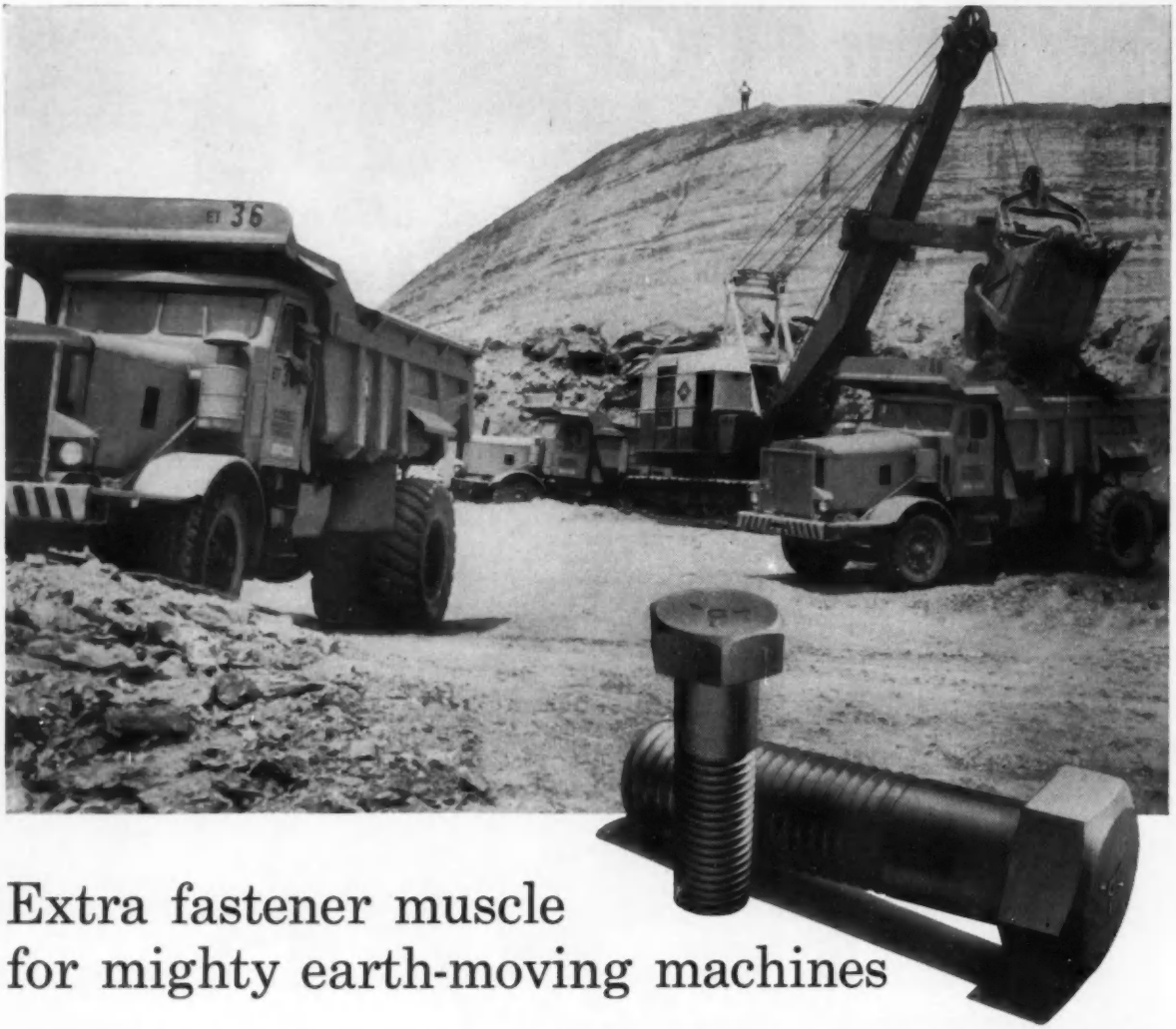
CWC

Campbell, Wyant and Cannon, one of the nation's largest production and jobbing foundries, produces grey iron, alloy iron and steel castings of consistent uniformity—quality castings that lower production costs! Because CWC castings measure up to such exact specifications, machine shop rejects are greatly reduced . . . and time and cost consuming inspection and re-working periods are kept to absolute minimums. Here, creative metallurgical engineering, quality control and mechanized methods assure improved product performance. CWC employs spectrographic analysis of metals, radiographing by million volt X-ray and various types of pre-production planning and tests to maintain the highest quality! On-time delivery of castings keeps your operations on schedule.

Write today for our booklet, "One Source"...it illustrates and describes the many types of castings CWC is now manufacturing and the methods used to produce them.

SIX FOUNDRIES LOCATED IN MUSKEGON, LANSING AND SOUTH HAVEN, MICHIGAN . . . READY TO SERVE YOU!

CLEVELAND STANDARD HEXAGON HEAD CAP SCREWS



Extra fastener muscle for mighty earth-moving machines

Power shovels, trucks, bulldozers—all take brutal shock loads and vibration, day in, day out. To reduce repairs and downtime to a minimum, leading manufacturers of earth-moving equipment specify Cleveland cap screws with confidence. These upset forged hexagon head cap screws put extra strength into every assembly, insure customer satisfaction.

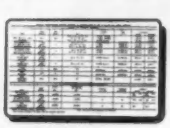
Cleveland standard hexagon heads are manufactured from various steels and in various tensile strengths. Included are extra-large diameters and long lengths. Bright and quenched and tempered steels in all standard sizes are ready for immediate delivery—alloy steels on short notice. Let our experienced engineers help you with your fastener problems. Remember, Cleveland has the most modern of production facilities and the world's largest stock of hexagon head cap screws.

TENSILE STRENGTHS OF CLEVELAND HEXAGON HEAD CAP SCREWS

Product	Size, in.	Tensile Strength, psi
Bright	Up to 7/8 incl. ⅛ to 1⅛ incl. Over 1⅛ to 1½ incl.	85,000—105,000 75,000—100,000 65,000 min.
Quenched & Tempered (SAE Grade 5)	Up to ½ incl. Over ½ to 1 incl. Over 1 to 1½ incl.	120,000 min. 115,000 min. 105,000 min.
Quenched & Tempered (SAE Grade 6)	Up to ⅝ incl. Over ⅝ to ¾ incl.	140,000 min. 133,000 min.
Alloy (SAE Grade 7)	Up to 1½ incl.	130,000 min.
Alloy (SAE Grade 8)	Up to 1½ incl.	150,000 min.
Bright	Over 1½ to 2½ incl.	55,000 min.
Quenched & Tempered	Over 1½ to 2½ incl.	90,000 min.
Alloy	Over 1½ to 2½ incl.	125,000 min.

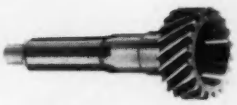
Note: Higher physicals, through use of selected alloys, can be supplied on special order.

GET YOUR COPY NOW — Pocket-size card giving you physical properties of Cleveland hexagon and socket head cap screws and Cleveland Place bolts.



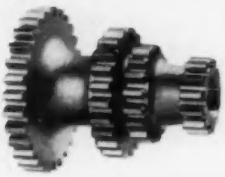
THE CLEVELAND CAP SCREW COMPANY
4444-12 Lee Road, Cleveland 28, Ohio
WAREHOUSES: Chicago • Philadelphia • New York • Los Angeles

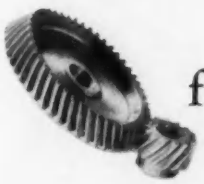
DOUBLE DIAMOND GEARS ARE BUILT...

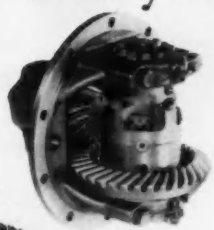


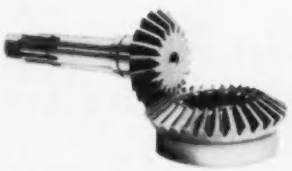
...to produce low installed cost

...to serve economically and

dependably on the job 

 for which you buy them

...and to do  credit to your product

and reputation 

The gear types shown above include helical gears, flywheel starter gears, straight bevel gears, straight spur gears, angular bevel gears, hypoid bevel gears, gear assemblies, zerol* bevel gears, spiral bevel gears, and spline shafts. Those are the types in which we specialize. Our sales people are gear engineers. Would you like to talk to one?

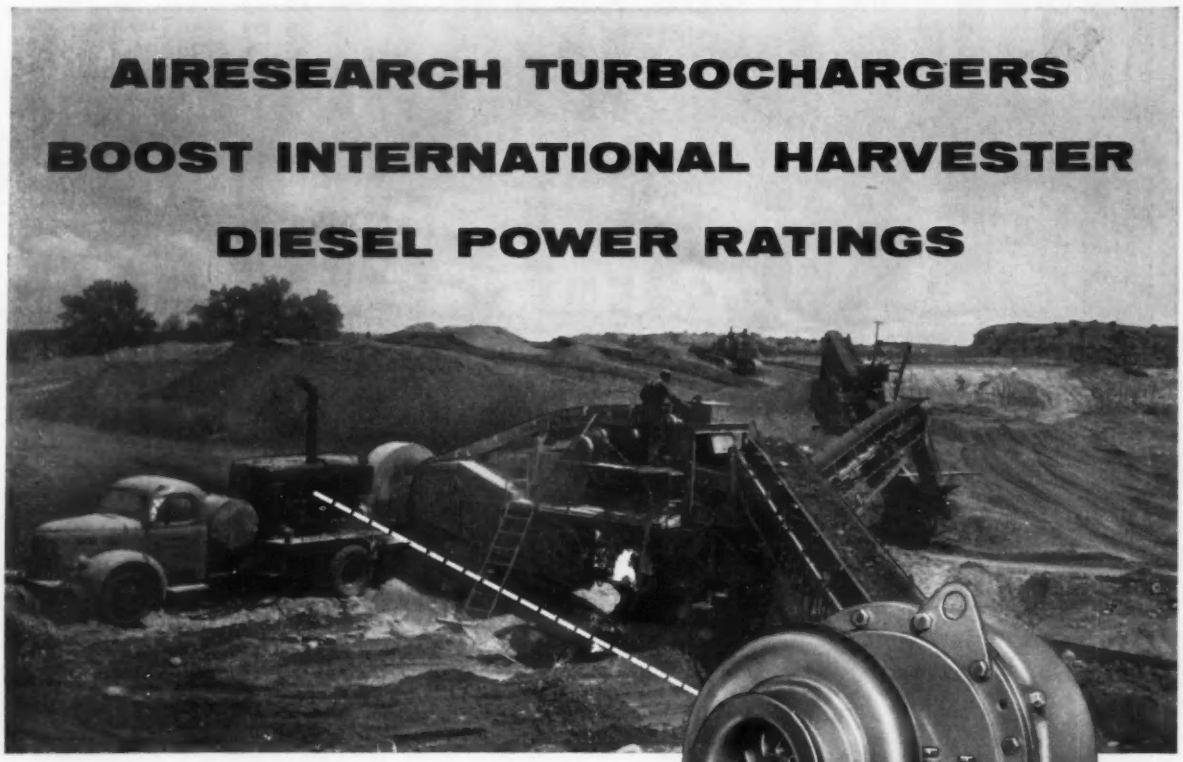
* Reg. U. S. Pat. Off.

EATON

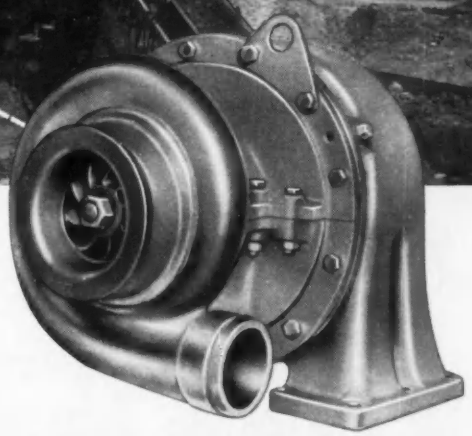
AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

AIRESEARCH TURBOCHARGERS BOOST INTERNATIONAL HARVESTER DIESEL POWER RATINGS



AIRESEARCH TURBOCHARGED *International Harvester UDT 1091 diesel is used to power this rock crushing equipment 5000 feet high at Pueblo, Colorado. Rock crushed is from 10 inches maximum to one inch minus with a 40% crush. The AiResearch turbocharger has increased the rock crusher's production by 20%, and not only boosted horsepower 20 – 30% over the diesel's previous output at that level but actually raised it over its sea-level rating. Approximately 1800 tons of rock are being crushed in eight hours by the turbocharged UDT 1091 compared with 1400 tons in an equal period with a non-turbocharged unit. The AiResearch turbocharged UDT 1091 prevents stalling under heavy loads and has operated for over 2500 hours at elevations in excess of 5000 feet with no "down time."*



AIRESEARCH C-60 TURBOCHARGER NOW AVAILABLE ON INTERNATIONAL HARVESTER UDT 1091 DIESEL ENGINE

Installation maintains sea-level output up to 12,000 feet with an important decrease in fuel consumption

AiResearch turbochargers have an outstanding record of operation in the field. Features include turbine wheels of unmatched efficiency, air-cooling which eliminates the need for complicated plumbing and ease of installation and maintenance. Thermal loading on the engine is lower by comparison than any other turbocharging or supercharging installation. Your inquiries are invited.

BASIC SPECIFICATIONS FOR AIRESEARCH TURBOCHARGERS					
MODEL	F-51	C-60	A-60	E-100	B-100
Diameter — in. nom.	10	11.5	15.25	15.1	15.4
Length — in.	10.5	12.9	16.75	14.7	17.1
Weight — lb.	40	95	125	112	135
Output — lb/min. (Standard Conditions)	29-51	30-60	38-60	50-100	60-100

THE GARRETT CORPORATION

AiResearch Industrial Division

9225 South Aviation Blvd., Los Angeles 45, California

DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS

How to be a magnetic tape recording expert

Introducing a useful new brochure on tape in instrumentation

Tape is the stuff of which memories are made – the versatile data memories for a jet propelled age of electronic miracles. If you are one who keeps up with times and techniques, it is a field well worth knowing. This new brochure gives a wide-angle view of the whole subject.

Typical pages

What kinds of applications do you think of when magnetic tape recording is mentioned? Sound recording, of course, and telemetering, if you are in that business. But what about simulating a rough road to test truck axles, controlling a milling machine to cut an aircraft wing section out of a solid billet, monitoring for a sudden occurrence that may happen only once in a year or two, recording data that can be reduced to graphs and tabulations without ever being touched by human hands? These and many more are described.

How significant is the fact that magnetic tape recording reproduces data in the same electrical form in which it was recorded? Enormously important, when you realize all the things the reproduced data can do that couldn't be done with the original signals or with the common forms of visual recording. For example the data can be slowed down to look at fast transients. It can be speeded up for wave analysis. It can be read out in any form. A tabular comparison between original signals and taped signals gives the full story. And a step-by-step pictorial demonstration of magnetic tape recording and reproduction puts the electrical-data idea into tangible, easily visualized form.

What does the data on magnetic tape look like? You can't see it, but the brochure will give you an idea of what it would be like if you could. And incidentally this may help to clarify the differences between various magnetic-tape-recording techniques.

Do you talk in tape's language? When is a tape recorder not a recorder? What is the difference between a channel and a track? What is a servo speed control? A much needed glossary gives the consensus of our views on terms.

For whom did we write this booklet . . . the expert, or the man for whom the whole subject is new? Both. It is written and illustrated so that any engineer or technically trained person can readily grasp the concepts and gain a broad understanding of the subject. If you are one of those who has already worked extensively with tape, you will find some new twists in the way the subject is explained, and perhaps ideas on new areas you hadn't explored. And incidentally, a copy of this brochure in some handy file will give you a good start in indoctrinating that new man in the department.

For your copy, write us today on your company's letterhead. Address your request to Department Y-5.

MAGNETIC TAPE APPLICATIONS BY AMPEX

5

ONE OF A SERIES

Series FR-100

Series 800 Mobile and Airborne

Model FR-300 Digital

Series PL-100 Loop Recorders

Series FR-1100

INSTRUMENTATION DIVISION

AMPEX CORPORATION

FIRST IN MAGNETIC TAPE INSTRUMENTATION

934 CHARTER STREET · REDWOOD CITY, CALIFORNIA

District offices serving all areas of the United States and Canada; Foreign Representatives in countries around the world.

What's he doing?

This is one of our field engineers, at work on a precision bearing installation for an experimental engine in a customer's plant.

He's one of the bearing experts from Cleveland Graphite Bronze, world's leading maker of sleeve-type bearings and bushings. Backing up on-the-spot field engineers like him is an advanced team of bearing design men, and a forward-thinking staff of scientists and technicians at the Clevite Research Center. After the engineering problems are solved, your orders are filled accurately and quickly by an up-to-the-minute, well distributed group of manufacturing units.

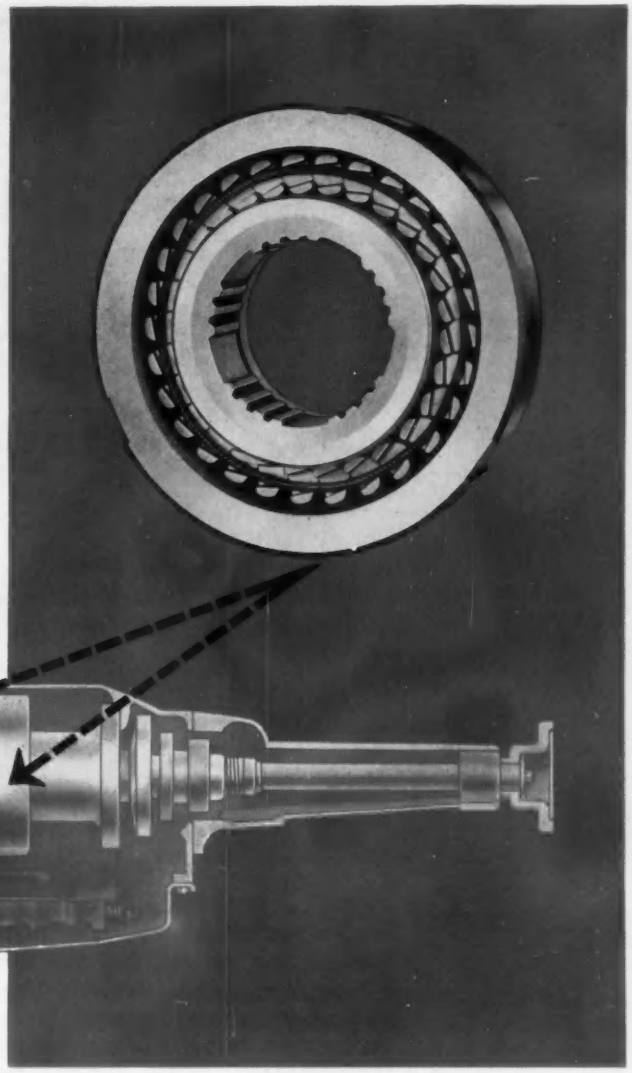
If you want this team working on your problems too, we'd be glad to hear from you.

CLEVITE
CORPORATION

Cleveland Graphite Bronze Co.
Division of Clevite Corporation
CLEVELAND 10, OHIO

CHICAGO DETROIT LOS ANGELES NEW YORK

What a difference a "D" makes...



IN SPRAG-TYPE CLUTCHES FOR AUTOMATIC TRANSMISSIONS

Automotive design demands component parts be stronger, lighter and smaller. Terms such as high capacity—less space—lightweight are familiar to automotive engineers and designers. These requisites are met by Formsprag for all automotive over-running clutch applications. With the Formsprag patented D-shaped sprag, a full complement of sprags may be used resulting in "higher capacity", "less weight" and "less space" than with any other type of over-running clutch.

In addition, D-shaped sprags are self-spacing, act independently and share the load equally. Moreover they allow insertion of a *full complement* of sprags in far less space. So, more engine torque can be transmitted per cubic inch of clutch displacement with Formsprag than by any other type of over-running clutch.

Formsprag's basically simple design permits economical prototype manufacture.

Automotive and aircraft manufacturers who demand the ultimate in over-running clutches specify Formsprag. Why not see for yourself what a difference a D makes. Next time you have a clutch application—specify Formsprag—world's largest exclusive manufacturer of over-running clutches.

FORMSPRAG COMPANY

23585 HOOVER ROAD, VAN DYKE (DETROIT) MICHIGAN

The only clutch that can give you full-complement performance.

A-13-7C

AN IMPORTANT STATEMENT

on selecting steels for heavy-duty transmissions in off-highway equipment:

"Field failures resulting from the use of substitute materials require replacement up to 7 times as often as when nickel alloy steels—proven by experience—are used in the original parts.

"We are unwilling to downgrade gear and shafting steels... the result would be expensive to users in terms of replacement costs."

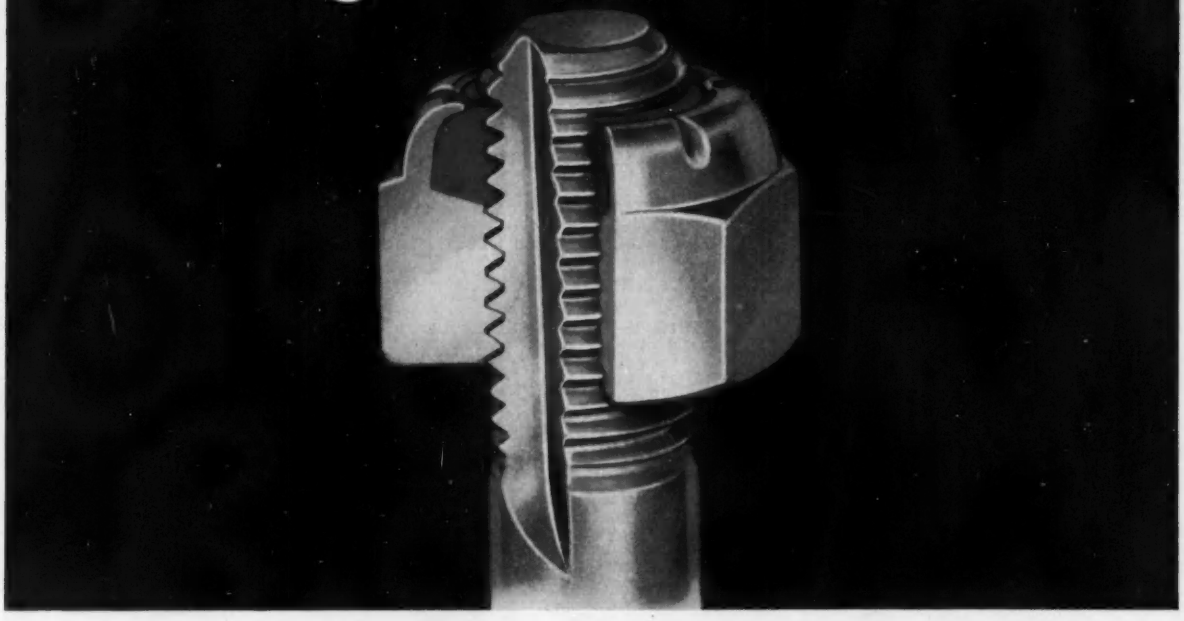
Fuller Manufacturing Company
Kalamazoo, Michigan

P. S. Fuller speaks from many years of experience building transmissions for the toughest service – in off-highway trucks, earth movers, cranes. Perhaps you too will find that nickel-containing materials are the answer to your metal problem. Check with Inco. All the information and help we can give are yours for the asking. That includes corrosion, high temperature and fabrication help... foundry service... technical publications . . . convenient sales and field information.

Nickel alloy steel gears and shafts in Fuller's 5-FS-1220 transmission help this Kenworth truck tote a 35-ton load of 48-foot logs up a hill in Vancouver, B.C. Fuller uses types 4820, 4320, 4620 and 2515 steels for carburized parts in this unit.

INCO THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

The nylon collared Elastic Stop® nut never damages bolt threads!



The nylon locking insert * will not seize threads, gall or remove plating

The red nylon locking collar is an integral part of an Elastic Stop nut. Oversize in diameter in relation to standard bolt tolerances, this insert grips the entering bolt threads with strong, smooth nylon fingers that dampen impact loads and resist turning under the most severe conditions of vibration or shock. The perfect fit between bolt threads and the locking collar also serves to seal off internal bolt and nut threads and to protect them against corrosion. Furthermore the nylon insert is impervious to gasolines, oils, salt atmospheres, cleaning compounds and common acids. The remarkable wear resistance of nylon plus its elastic recovery makes Elastic Stop nuts reusable through more than a hundred on and off cycles.

Because an Elastic Stop nut is a one-piece unit it is less expensive to install than castellated nuts and cotter pins, or double nuts. Equally important, it is a *stop* nut that *locks at any position on the bolt* without requiring secondary "safety" devices; it is simple to adjust precisely—it is easily wrenched off or readjusted. Elastic Stop nuts have been used by American industry since 1930 to solve the toughest applications on railroad, automotive, earth moving and farm equipment, as well as on all types of electrical machinery.

Elastic Stop nuts are available in sizes ranging from a watchmaker's 0-80 through 3″, and in many standard finishes and materials including carbon and stainless steels, brass, duronze and aluminum.

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA®

also maker of the ROLLPIN™

*The Red Locking Collar is a Registered Trademark of ESNA

Elastic Stop Nut Corporation of America
Dept. N27-775, 2330 Vauxhall Road, Union, N. J.

Please send me the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Company_____

Street_____

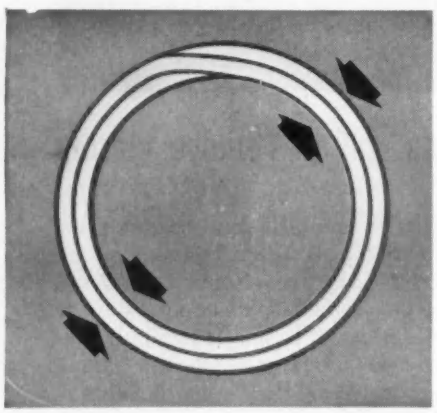
City_____ Zone____ State_____

Only Bundyweld steel tubing

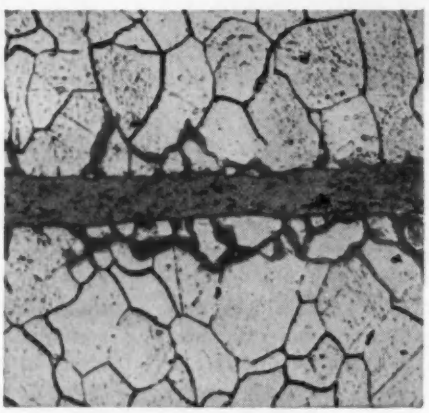
Here's why Bundyweld STEEL Tubing is used on 95% of today's cars

The illustrations below reveal why Bundyweld is specified by automotive manufacturers where strength and durability of tubing are essential. Bundyweld is the only tubing double-walled from a single metal strip. This exclusive process gives Bundyweld superior strength properties. Yet, because of the conditions under which Bundyweld is brazed and cooled, it is uniform and easy to fabricate.

BUNDY TUBING COMPANY, DETROIT 14, MICHIGAN



With Bundyweld's beveled edges and single close-tolerance strip, there's no inside bead. The tubing is uniformly smooth, both inside and out. It fabricates easily; can be bent to short radii. Copper coating, inside and out, facilitates soldering and brazing operations.



This view of Bundyweld's copper bond (enlarged 300 times) shows how the copper actually alloys with the steel . . . through 360° of wall contact. That's the secret of Bundyweld's outstanding resistance to high pressure and vibration fatigue.

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

←

NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

can take punishment like this!

When automotive manufacturers attempt to build a hundred thousand miles into their cars, they know they must use only the highest quality parts. That's why Bundyweld STEEL Tubing is used *in 95% of today's cars, in an average of 20 applications each.* Only STEEL tubing is tough enough, rugged enough to take constant wear and tear.

Extra-strong Bundyweld Tubing is specified for hydraulic brake lines, to assure safe stops; for oil lines, to save costly repairs; for gasoline lines, to assure leakproof performance; for push rods, to produce more powerful overhead valve engines.

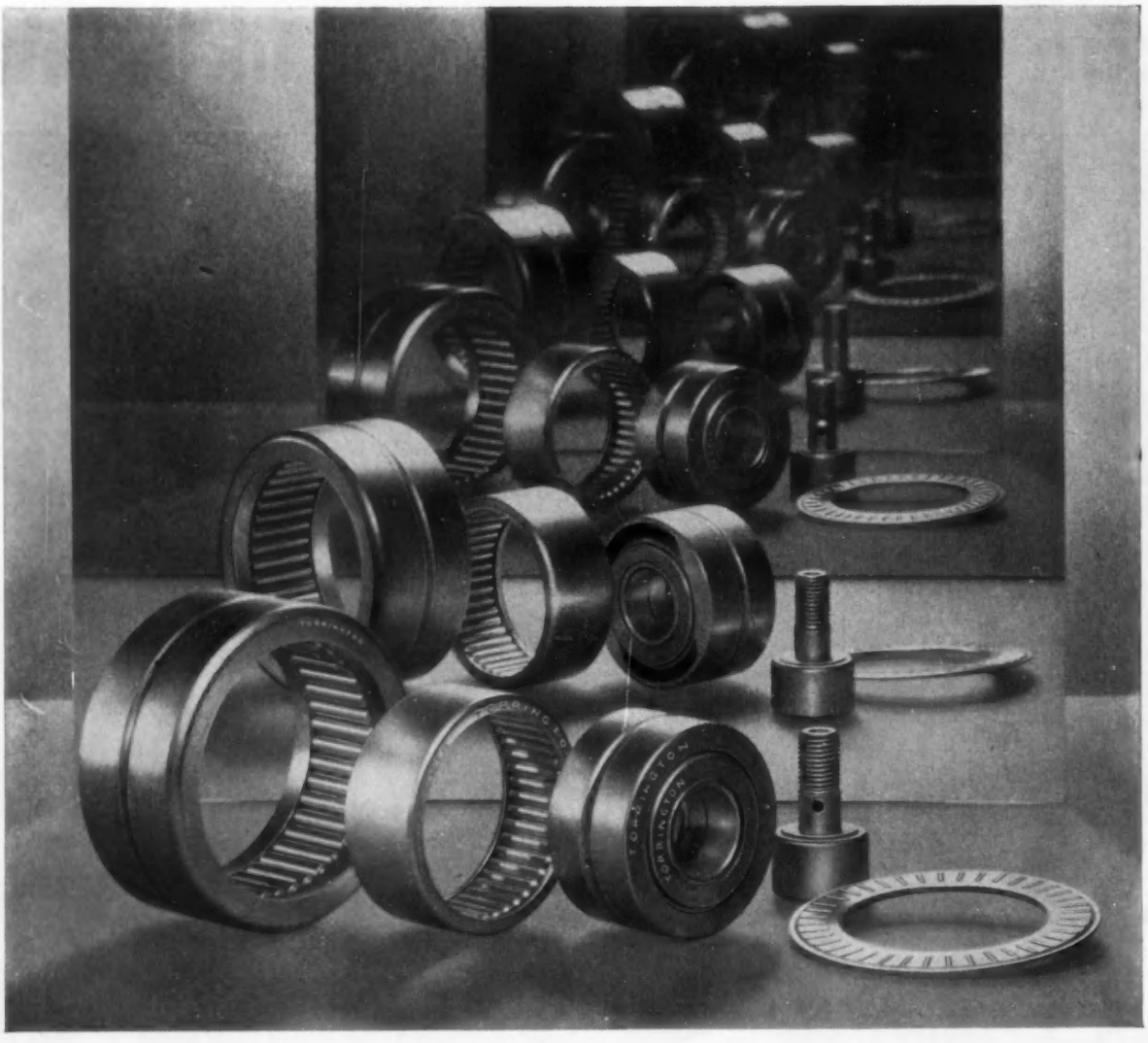
Backed by expert technicians, Bundy offers advanced fabrication facilities and prompt, dependable delivery. Let us help you with your tubing problems. Write today for additional information.

There's no real substitute for

BUNDYWELD® TUBING

Bundy Tubing Distributors and Representatives: ***Massachusetts:*** Austin-Hastings Co., Inc., 226 Binney Street, Cambridge 42 • ***Pennsylvania:*** Rutan & Co., 1 Bala Ave., Bala-Cynwyd • ***Midwest:*** Lapham-Hickey Steel Corp., 3333 W. 47th Place, Chicago 32, Ill. • ***South:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg., Chattanooga 2, Tenn. ***Southwest:*** Vinson Steel & Aluminum Co., 4606 Singleton Blvd., Dallas, Texas • ***Northwest:*** Eagle Metals Co., 4755 First Avenue, South, Seattle 4, Wash. • ***Far West:*** Pacific Metals Co., Ltd., 2187 S. Garfield, Los Angeles 22, Calif. • Pacific Metals Co., Ltd., 3100 19th Street, San Francisco 10, Calif.

Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.



For new perspectives in **NEEDLE BEARING** *design and performance*

. . . *look* to Torrington, pioneer in the development of every type of precision Needle Bearings.

Using carefully selected quality steels, and the most modern manufacturing methods, Torrington has developed a complete range of types and sizes of Needle Bearings for every use. There are special designs for rotation, for oscillation, even thrust applications! There are aircraft types, cam followers, and heavy duty types. Yet their unit cost is low, bringing anti-friction performance with economy.

Precision manufacture and the full complement of rollers that provides maximum radial capacity in minimum cross section make Torrington Needle Bearings top performers in the most rugged applications.

Little wonder their use has spread to countless applications in every field with outstanding success. Have you considered them for your product? Send for further information today.

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.

TORRINGTON BEARINGS

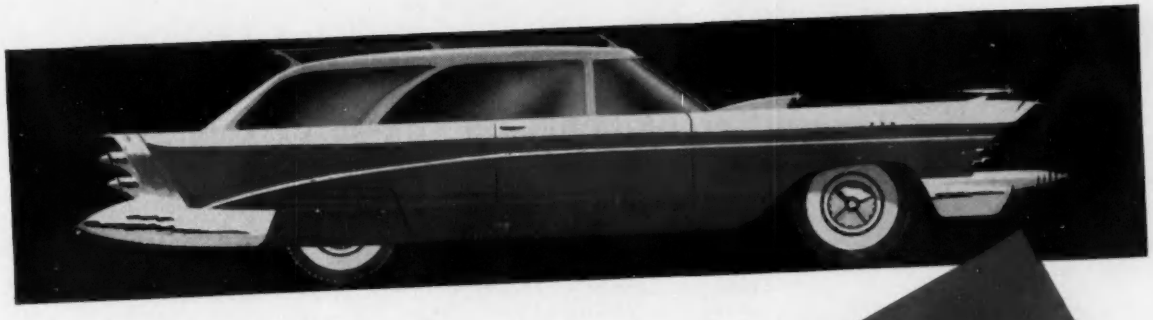
Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

CLEVELAND

**Universal Joints,
Propeller Shafts and
Power Take-Off Joints**

...In Step With The Modern Trend

New, more powerful engines, lower silhouette designs and smaller clearances of today's motor vehicles demand a new type of propeller shaft. It takes a plenty rugged assembly of much higher capacity, capable of working in a much smaller radius, to meet today's exacting requirements.



Having anticipated this trend to super power and super sleekness, "Cleveland" is ready with many new series of propeller shafts. These have greatly *increased* strength and *decreased* swing diameter and also incorporate the many advantages of the celebrated 32 tooth conventional spline shaft pioneered by "Cleveland".

Look to "Cleveland" for propeller shaft and universal joint requirements. We'll welcome the opportunity to work with you.

Since 1912

Cleveland Steel Products Corporation

Automotive Division

**16025 Brookpark Road
Cleveland 11, Ohio**

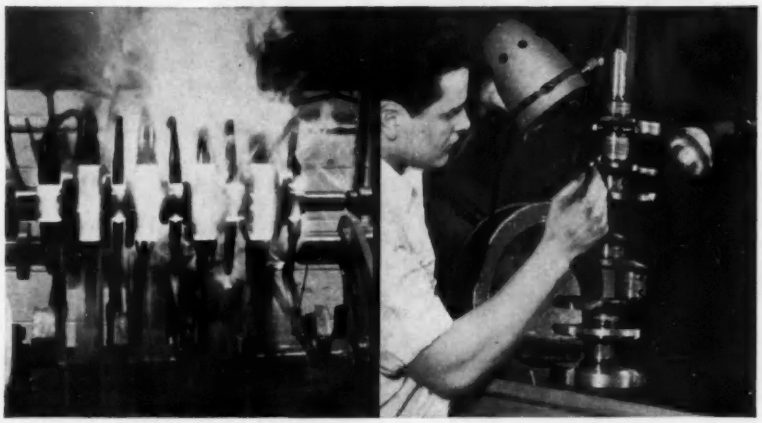
Case Studies:

NONDESTRUCTIVE TESTING SYSTEMS

On-the-Spot LEAK TEST

New Zyglo Portable Kit provides the most convenient and sensitive leak tests, on-the-spot and in-place. For process tanks, liquid lines, tank weldments during fabrication, on cast housings, etc. Just spray Zyglo Penetrant on one side, as in this weld test.

And find the leak! The supersensitive Zyglo-Pentrex ZL-22 quickly penetrates through faulty weld and shows as brilliant glow, looking at other face of weld under Zyglo Kit's black light.



Hardening crankshaft bearings with flame heat treating at National Induction Heating, Inc., Hazel Park, Mich.

Before and after heat treating, automotive crankshafts are inspected with Magnaglo for cracks.

How Nondestructive Testing Backs Unconditional Guarantee of Heat Treating

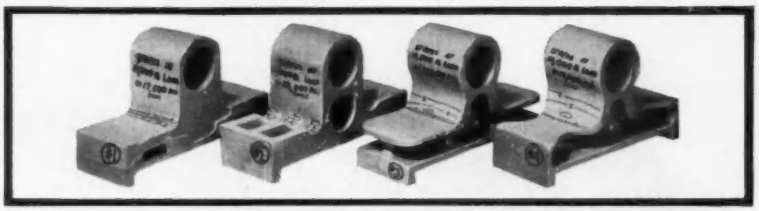
Backing up heat treating service with a 100% customer guarantee takes tight control—especially when the parts treated are critical, for planes and tanks.

Testing with Magnaflux-Magnaglo® makes such a guarantee entirely practical for National Induction Heating, Inc., of Detroit. Parts are tested *before* and *after* heat treating, since treatment may release stresses around inherent defects or produce thermal cracks in previously sound materials. Either way, Magnaflux-Magnaglo will find the defects!

Initial tests are made on "green" stock and on the first few treated parts to minimize scrap losses. If significant flaws or cracks are detected, the cause can often be corrected by slight changes in design or heat treatment before the full run is processed. This means real savings for customers.

Magnaflux Testing Systems, using many various methods, are reducing costs in hundreds of in-process operations—at all stages of production. Wisely employed to find serious cracks early, they save time, labor and dollars which are otherwise wasted in working parts fit only to be scrapped. With Magnaflux' positive detection, *you* decide which defects are serious and how to correct them. You never need pass a bad part, or scrap a good one for harmless imperfections. *Result: Consistent quality levels at lowest cost to you.*

For further information on the many ways you can save money with Magnaflux Testing Systems, please write today for our booklet, LOWER MANUFACTURING COSTS.



STRESS ANALYSIS BRINGS STRONGER, LOWER-COST CASTING

Using Magnaflux' Stresscoat brittle coating for experimental stress analysis, foundries now suggest design improvements which reduce cost and improve the product. In this typical case, the original casting, a truck fifth-wheel support, #1 (at left) required three complex sand cores, was expensive, had high stress concentration. Two intermediate designs, analyzed with Stresscoat, led to the new standard part, #4 (at right). It is 9% cheaper, 15% stronger, and much easier to pour. The result: Better castings and new business for the foundry.

THE HALLMARK OF QUALITY IN NONDESTRUCTIVE TEST SYSTEMS

MAGNAFLUX CORPORATION

Write for complete details concerning any of the above case studies, or ask for our new booklet on Lower Manufacturing Costs.

Take Your Inspection Problems to the House of Answers . . .

MAGNAFLUX CORPORATION

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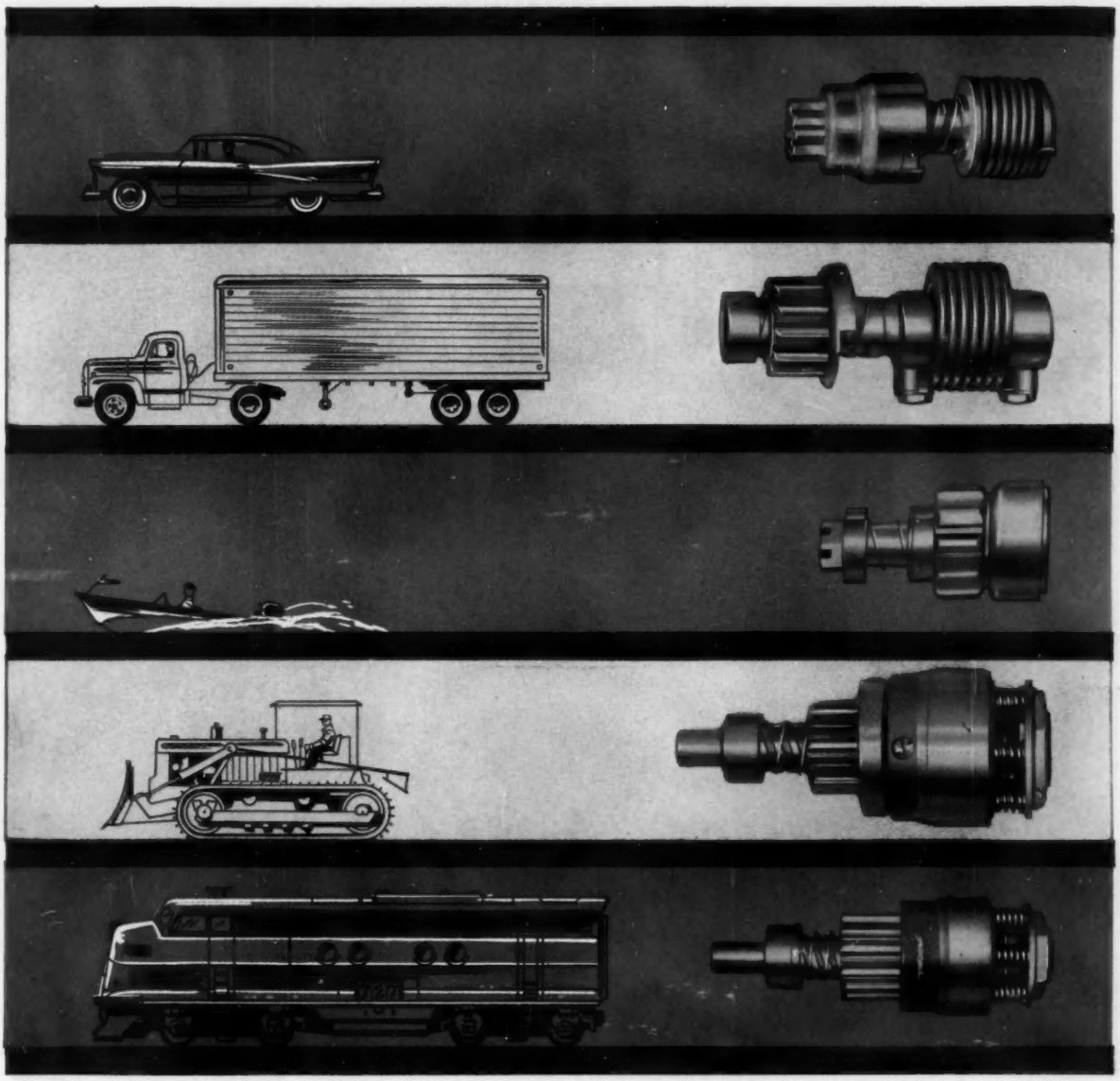

BIG OR SMALL . . . BENDIX DRIVES START THEM ALL

Throughout the world of transportation it's an accepted fact that *you start with Bendix!* And it's not surprising. Bendix* Starter Drives have been synonymous with dependability for fifty years in the automotive field. They've proved themselves just as reliable on submarines, aircraft, earth movers, outboard motors, helicopters. In fact, every type of internal-combustion engine ever built has used a Bendix Starter Drive. Hospitals use Bendix Drives to activate their stand-by equipment. Air raid sirens across the country are started with Bendix Drives. It's logical to believe that such universal acceptance indicates a standard of quality which no other manufacturer has been able to match. Need we say more?

*REG. U. S. PAT. OFF.

Bendix-Elmira, N.Y.
ECLIPSE MACHINE DIVISION

Bendix
AVIATION CORPORATION

WHY DOUGLAS ENGINEERS AND SCIENTISTS GO FURTHER . . .

At DOUGLAS, you'll work to expand the frontiers of knowledge in today's most advanced missiles program

1. Nike 2. Honest John 3. Sparrow 4. Thor IRBM 5. Secret 6. Secret 7. Secret 8. Secret

It's no secret that we're in the "missile business" to stay . . . with sixteen years behind us and an ever-expanding future ahead

There can be no mightier challenge than to be assigned to any one of the major projects now under way in the Douglas Missiles Division.

Some – like Nike and Honest John – have pioneered missile development. Others on which Douglas engineers are engaged are extending the horizons of present-day development . . . cannot be mentioned for reasons of national security.

These are the projects that require engineers who are looking far beyond tomorrow. You will use all of your talents at Douglas and have the opportunity to expand them. Your only limitations will be of your own making. Douglas is an engineer's company . . . run by engineers. Make it your working home and build an important and rewarding future in your field.

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For complete information, write:

E. C. KALIHER
MISSILES ENGINEERING PERSONNEL MANAGER
DOUGLAS AIRCRAFT COMPANY, BOX 620-O
SANTA MONICA, CALIFORNIA

McCORD GASKETS

Are *Better Gaskets*

Because of Better Engineering

McCord gaskets seal tite — seal rite because they are engineered to accomplish that purpose better than any other gasket made.

You can depend on McCord gaskets . . . the Industry has for over 60 years.

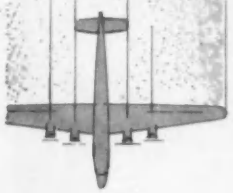
McCORD CORPORATION • Detroit 11, Michigan

You Can Depend On McCORD GASKETS . . . Most Car Makers Do

HERE'S PROTECTION

LISLE *Magnetic* CHIP DETECTORS

FOR AIRCRAFT ENGINES



Install *Lisle Magnetic Chip Detectors* in aircraft engines and accessory units to provide a quick, positive means of determining the presence of ferrous metal chips or particles broken free of vital gears, bearings or other internal components.

Attracted to the *Detector* by its powerful Alnico magnet, the particles bridge an electrically insulated gap between the magnet and the *Detector* body.

A ground check with a continuity tester — without removing the *Chip Detector* from the installation — indicates the accumulation of metallic particles.

Many major airlines and engine manufacturers specify *Lisle Magnetic Chip Detectors* for advance warning of internal breakdowns *before* in-flight failures.

Four *Chip Detector* types illustrated above. (*Lisle* engineers will design the one that fits your specific requirements.)

WRITE FOR DATA AND PRICES

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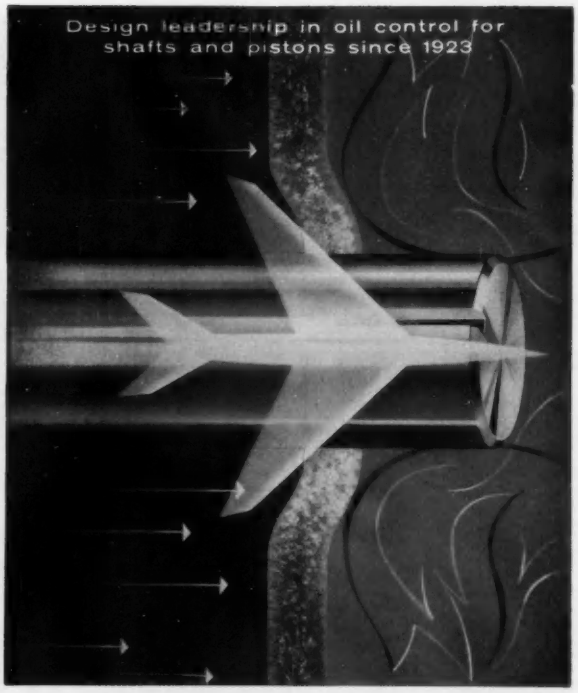

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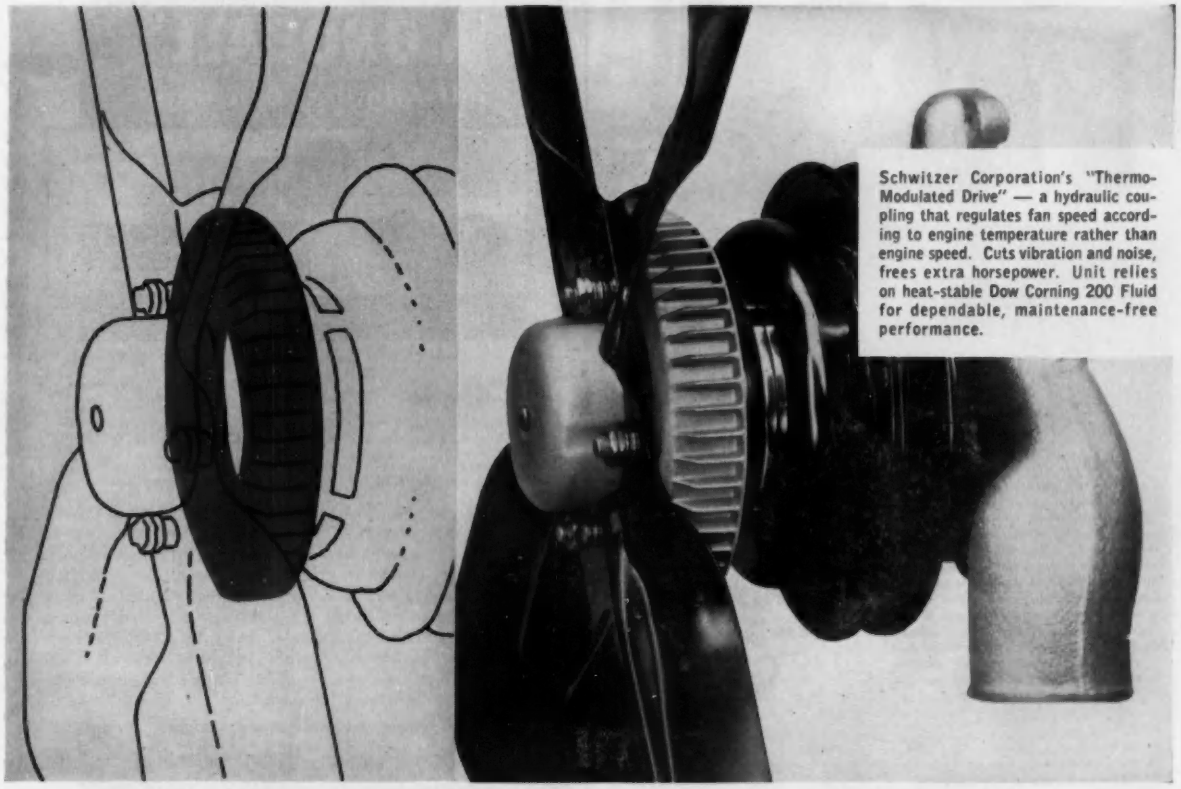

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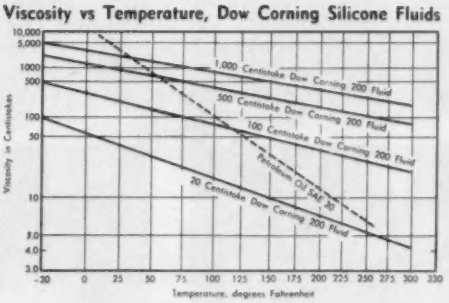

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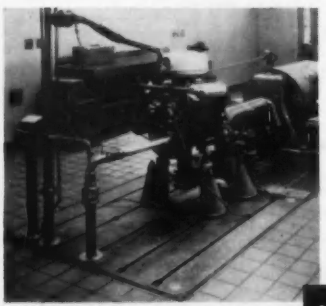

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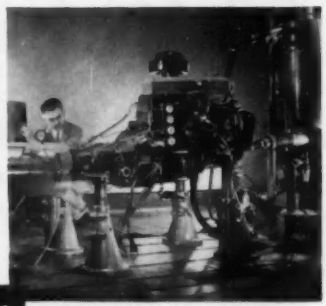

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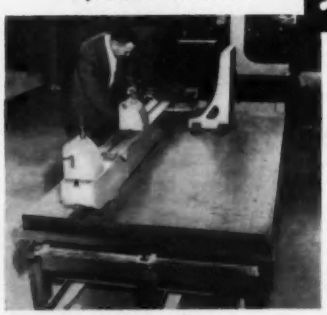

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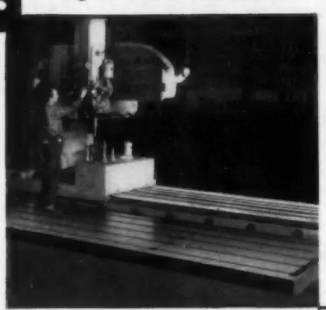

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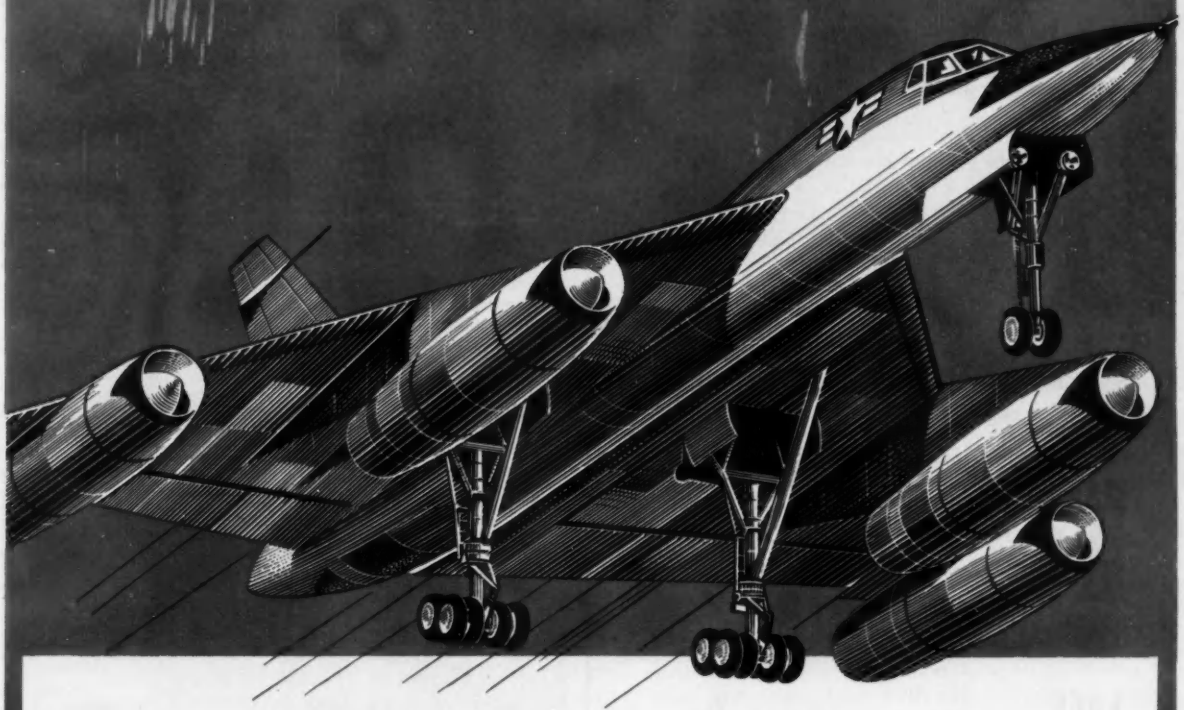

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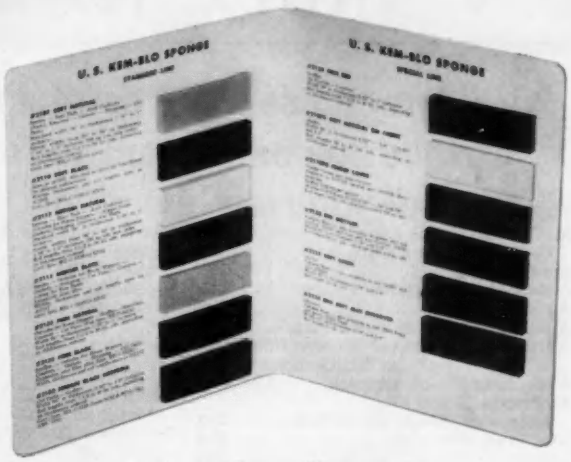

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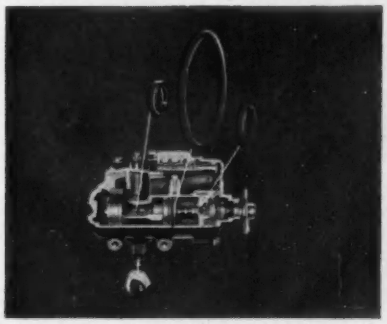
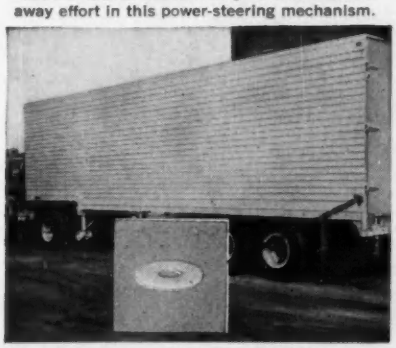


Seals, piston ring and lock nut seal ring of TEFLON resins substantially reduced break-away effort in this power-steering mechanism.



Thrust washers used in trailer-door hinges are made of TEFLON resins. They stand up to rugged usage and require no lubrication.

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Components of Du Pont TEFLON tetrafluoroethylene resins provide a combination of advantages for automotive design that no other single material offers. Many problems of maintenance may be eased, or eliminated, with them.

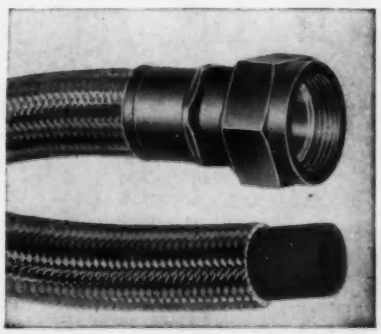
Lubrication is an example. Due to the "self-lubricating" properties of TEFLON resins, parts such as bearings, bushings and washers can frequently be buried within an assembly or sub-assembly without any need to provide oil ducts or grease fittings. Due to the toughness and mechanical strength of TEFLON resins, such parts are usually rated for the lifetime of the unit. In frictional contact with a metallic part, a molecular layer of the resin is deposited on it. Friction may be reduced to no more than that of ice against ice.

TEFLON 1, TEFLON 5 or TEFLON 7X are outstanding gasketing, sealing and packing materials. They are widely used in the chemical industry today for equipment handling extremely corrosive materials, and can withstand temperatures up to 500°F. TEFLON resins are completely unaffected by any type of automotive solvent or chemical or by the reaction products of internal combustion. No fuel or lubricant has any effect on — or is affected by — TEFLON resins. They will not deteriorate or swell under moist or wet conditions . . . will not undergo embrittlement even at arctic temperatures.

The truly remarkable characteristics of TEFLON resins may well be the means of helping you take a long step forward in design. An informative set of data and examples has been compiled, expanding on the design theme. It's free for the asking.

Typical properties of TEFLON® tetrafluoroethylene resins

Tensile strength, 73°F.	1,800 psi
170°F.	1,100 psi
Modulus of elasticity, 77°F.	58,000 psi
Shear strength	3,800 psi
Impact strength, −70°F.	2.0 ft.-lb./in.
73°F.	3.0 ft.-lb./in.
Stiffness, 73°F.	60,000 psi
Flexural strength, 73°F.	Did not break in standard test
Coefficient of friction	0.04
Coefficient of linear thermal expansion per °F.	5.5×10^{-5}
Thermal conductivity	1.7 B.T.U./hr./sq. ft./°F./in.
Water absorption	0.01%
Flammability	nonflammable
Specific gravity	2.1-2.2
Resistance to weathering	Excellent
Dielectric strength, short time (80 mils)	400-500 v/mil
Dielectric constant, $60\text{-}10^8$ cycles	2.0
Chemical resistance	Inert to nearly all chemicals



Hose of TEFLON resins is impervious to fuels, oils, greases and hydraulic fluid. Moisture, sub-zero cold and tropical heat will not damage TEFLON resins.

TEFLON®

is a registered trademark . . .

TEFLON is the registered trademark of the Du Pont Company. It should not be used as an adjective to describe a product of another concern; nor may this registered trademark be used in whole, or in part, as a trademark for any product.

SEND FOR INFORMATION

For additional property and application data on Du Pont TEFLON tetrafluoroethylene resins, mail this coupon.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.
Room 57, Du Pont Building, Wilmington 98, Delaware

Please send me more information on Du Pont TEFLON tetrafluoroethylene resins. I am interested in evaluating this material for _____

Name _____

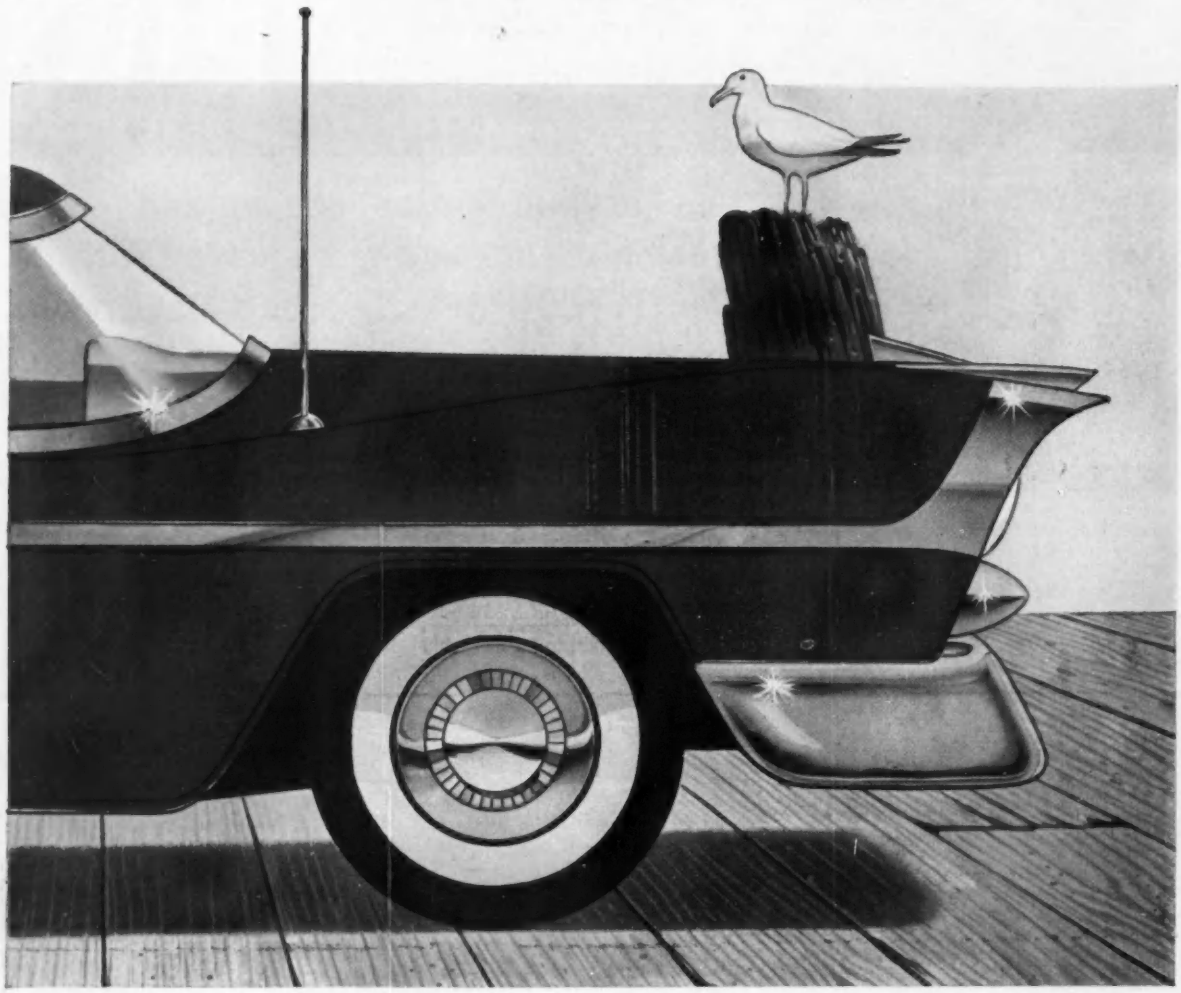
Position _____ *Company* _____

Street _____

City _____ *State* _____

Type of Business _____

In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec



The beauty of Crucible stainless steel is its high strength and lustre

How do you get unlimited flexibility in designing tomorrow's body and parts? You need a metal with beauty, strength, rigidity, lightness and superior resistance to corrosion. You need stainless steel.

Already, roof panels and radiators are being made with this versatile metal. Tomorrow, you may even design stainless steel posts and pillars, chassis frames, floor and roof deck panels. There may even be ceramic coatings for stainless that will provide dramatic new textural and tonal combinations.

Specify *Crucible sheet and strip* when you order stainless steel. Crucible promptly supplies standard grades and finishes in practically any width and thickness. And if design or fabrication problems arise, Crucible engineers and research teams will cooperate with you in every way.

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A swirl of oil slows you down

without using the service brakes

This Allison transmission, now available on medium- and heavy-duty trucks, is a torque converter, six-speed automatic transmission, and hydraulic retarder all in one.

A turbulent swirl of oil inside the transmission does the trick – multiplies engine braking power. You control the slowdown with a separate foot pedal. The more you depress, the slower you come down. Service brakes are saved for normal and emergency stops.

This transmission was developed by Allison from the famous TORQMATIC Drives that have proved themselves in years of service in the heaviest off-highway haulers. It is the first automatic transmission specially designed for medium- and heavy-duty on-highway trucks.

The transmission automatically compensates for load, grade, terrain and speed. It always selects the right gear at the right moment and shifts under full power.

Under way, your truck automatically locks up in direct drive in any gear. You enjoy top fuel economy.

Even in the heaviest crosstown traffic it makes driving easier. And your trucks make better time.

You save money. You save enough in brake linings and tire wear alone to more than pay for this transmission.

Allison automatic transmissions are now available on Chevrolet and other leading trucks. TORQMATIC Drives, designed and built by Allison, will soon be available on many other makes. Ask your truck dealer.

ALLISON DIVISION OF GENERAL MOTORS, Indianapolis, Indiana

GM TORQMATIC *Allison* TORQMATIC DRIVES

ANNOUNCING!

Increased capacity ratings for Timken® bearings

THE Timken Roller Bearing Company announces an increase in the capacity ratings of most series of Timken® tapered roller bearings. Increases range up to 39%. Most are in the neighborhood of 10%. Some are negligible.

Permits Use of Smaller Bearings

This increase in capacity ratings makes it possible for many of you to use smaller bearings. Your products can be made more compact. You can save weight. You may be able to reduce the size of your shafts and housings. And you may be able to use Timken bearings in new applications where they have not been practicable in the past.

3 Reasons for Increases

What led to these increases in Timken bearing capacities? Three things:

First, a careful review of more than 6,000 different laboratory studies of Timken bearing performance on fatigue life machines. From these exhaustive studies, conducted on an organized, scientific basis since 1924, we keep learning more and more about predicting bearing life.

Second, refinement in the method of analyzing these studies mathematically.

Third, a careful review of the life of millions of Timken bearings in the field.

How Much Can This Save *You?*

To find out how the new capacity ratings affect the types and sizes of Timken bearings in which you are interested, call your Timken bearing representative or write our Engineering Department. We'll be glad to work with you at the drawing board stage. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

TIMKEN
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TAPERED ROLLER BEARINGS ROLL THE LOAD